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Digging Up the Asphalt by Means of Hot Spades.

Loading a Railway Truck Direct From the Mine.

ASPHALTUM MINING AT CARPENTERIA, CALIFORNIA.—[See page 302.]

Modern Means of Investigating Mental Processes*

A New Diagnosis for Hidden Mental Taint

By William J. M. A. Maloney, M.D., F.R.S.

A FEW decades ago people were mad only when they were officially committed to institutions for the insane. A man's sanity depended upon his harmlessness to society, and upon the tolerance of his family. Even in those halcyon days the profane labeled Julius Cæsar, St. Paul, Mohammed, and Napoleon as epileptics, and therefore, as degenerates; dissected the mind of saint and of genius, and found it perverted, debased, and disordered; unceremoniously hustled the great over the borderland; but left the mediocre complacent that the mad were not they, but the others. Then the comprehensive derogatory terms, neuropath and psychopath, were invented to vex and disturb this serenity. And now, zealous sleuth-like field workers track stigmata so keenly that degeneracy is found to be nearly as prevalent as original sin.

The cause of all the pother is the absence of a standard of sanity. We have no adequate definition of a normal mind. Among individuals vast differences of capacity and temperament exist. To the same mental stimulus no two minds yield identical reactions. To the same mental stimulus even the same person never responds twice in exactly the same way. Every mind varies from hour to hour, and this mental change continues always. When stimulated to greater effort, to loquacity, irritability, restlessness, or excitement, we pass through a maniacal phase of mental activity. When weary or listless, dull or sad, we pass through a period of mental depression. In our daily moods we thus enact mildly the cycle of what, when marked, is called maniac-depressive insanity. Or if we are inconstant in energy, or fickle of purpose; if in commerce we sigh for journalism; if medicine beckons us from priesthood; if art lures us from law; if we are unsettled and migratory as regards domicile; if we are pedantic in speech, faddists for food, eccentric in dress, precise in manner, or mystical in religion, if we indulge in a chequered career, or a sentimental journey, or Shakespeare's English, or vegetarianism, or non-fashionable attire, or punctilious politeness, or in Buddhism, we show affinities with dementia præcox. Or, again, if we cherish, as we all do in our secret hearts, the conviction of our direct descent from an Irish king, or a pilgrim father, or a Dutch settler; if we fondly imagine we could bankrupt a Morgan, outbuild a McKim, rule a Roosevelt, outsail a Nelson or outmaneuver a Grant; our folly veers toward paranoia. All the morbid phases which we recognize under the magnification of insanity we can detect, as through a reversed telescope, in states of mind which we accept as normal.

Where does the normal end and the morbid begin? Can we determine where idiosyncrasy merges into madness, where eccentricity becomes irrationality, where individualism lapses into lunacy, where pedantry ripens into dementia, or where fanaticism matures to mania? We may regard the average as the normal mental state but we may not regard those who are either above or below the average as necessarily abnormal. Psychologists are still struggling to fix the standards of the average normal mentality of various ages. When these standards are definitely settled, we shall be able to interpret facts concerning an individual's mental processes only upon a basis of personal opinion, and not of knowledge. We shall be able to compare an aberrant individual with the general average, but we shall not know what was that individual's normal mental state, nor what was the amplitude of his normal intellectual variation. We cannot detect slight abnormal changes: and when severe changes occur, we cannot tell how far removed from former behavior the new morbid attitude is. In cases of pronounced aberration our difficulties are merely scientific. Even a jury suspects the sanity of one who seriously claims identity with Cleopatra, a poached egg, or the Prophet Elijah. But upon less bizarre conditions, a Solomon would often need to sit in judgment. Murder has been urgently committed by those who, suspected and confined in institutions for the insane, had just gained a judgment of sanity and freedom from an expert and prejudiced examiner.

The question of the delimination of sanity from insanity, of competency from incompetency, of responsibility from irresponsibility, daily agitates our courts, bewilders our jurists, confuses medical testimony, and embarrasses the expert alienist, as if he were a professional witness. When we are confronted with an individual can we tell about his mental state anything that is not evident to the layman's common sense? What can we do beyond adducing scraps of evidence of the person's intellectual capacity, and offering a comparison with more or less unverified average standards which are alleged to prevail among the citizens of some European town or country? Can we bring forward nothing positive, nothing conclusive, nothing of absolute value?

We have two methods by which absolute knowledge may be gained. The first, the psychoanalytic method, endeavors to resolve the mental state into its fundamental constituents, to disintegrate the existing mental structure. The necessary data for the analysis are obtained from the dreams, reveries, reminiscences, and thoughts of the investigated person together with his reactions to stimulus words. These data are analyzed, correlated, and synthetized. What is obscure is deemed symbolic of erotic imagery. The prevailing content of the person's mind is thus ascertained.

Then by certain postulated mechanisms such as suppression, repression, and conversion, the origin of the content is explained, and its development outlined. The integral portions of the content are neatly labeled according to accepted nomenclature as complexes, and all is now ready for "sublimation" or the proper affective reaction to heal the mental trauma.

The apostle of this alluring method is Sigmund Freud of Vienna. Breuer came before, but he was merely "as the voice of one crying in the wilderness." There is no Freud but Freud. The faithful follow him as the wise men followed the stars. Freud has taught us that the key to mental processes lies in the study of the evidences of these processes. He has emphasized these evidences, and has given us a method by which to study them. Psychoanalysis may not be a perfect method, but it is the most perfect that we possess. It is indeed our only method, but when we use it in the ancient, stereotyped, slipshod fashion we fortunately do not call it psychoanalysis. Freud sifts the results of his thorough and scientific analysis, and discovers psychic traumata. Doubtless many psychic traumata have a sexual basis. But that all should so arise; that special mechanisms should be invoked so as to procure an inevitable sexual end product; and that every non-organic morbid mental state should evolve from the sphere only of the sexual instinct and not from the other ruling passions, such as gain, self-preservation, etc., naturally deter many physicians from closely scrutinizing Freud's tenets. Some among these conservatives realize the value of the method, admire the ingenuity, and half believe the truth of a few of Freud's mechanisms. But the disgusting and wild interpretations (interpretations wanting in reason, in decency, and in purpose), which are trumpeted as Freudian by some of his ignorant, self-styled disciples, dissuade them from further inquiries. Up to the present day, Freud has had practically only one adversary, Isserlin. Most other physicians have been either content to ignore or, while more or less acknowledging the value of Freud's methods, to repudiate his inferences and avoid controversy on subjects which naturally offend their susceptibilities. But there are not a few rabid antagonists whose virulent opposition springs from a veritable Freud *Angst*.

The persistent courage and indefatigable ingenuity of Freud no less than the zeal, number, and talents of his followers, merit that his teachings be judiciously considered. If the foolish and merely prurient of the writings of the ignorant Freudians be set aside, and if Freud's doctrines, as enunciated by himself, and by the many distinguished scientists among his adherents be studied, one tithe of the energy spent now in vituperation would settle forever the value of the whole Freud system.

The other method is largely due to Wundt and Emil Kraepelin who with Sommer, Rivers, Hoche, Aschaffenberg, and others have used it to convert psychology into an exact science. In this method all mental processes are measured just as we measure blood-pressure, or visual acuity, or urea excretion.

An individual's capacity for simple mental operations, such as memorizing, counting, choosing, perceiving, associating, etc., is measured. A large number of tests are made so as to insure that neither freshness, nor fatigue, nor attention, nor boredom, nor practice, nor noviceship will unduly influence the results, and the average of all phases of mental activity will be obtained.

But intellects react differently to the same disease, and the same disease is a variable quantity. No normal except the concerned individual's normal can be used as a reliable standard. So this method has not yet yielded the hoped-for enlightenment. It is, however, eminently suited for the study of normal subjects in whom artificial alteration of the mental state is about to be produced by means of drugs. The person's normal intellectual capacity is determined; the drug, tea, coffee, bromide, or alcohol, is then given, and the departure from the ascertained normal is measured. The method is often modified and curtailed in practice; only one preliminary testing is then done, the drug is administered immediately, and then the mental capacity tests are repeated. Of course, innocuous fluids of similar taste to the alcohol, and other experimental substances, are occasionally substituted unexpectedly, in order to control the results. The value of this work of the Kraepelin school is evident even to the layman and the jurist. If, under the influence of alcohol, a man commits crime, it is nowadays not enough to say that alcohol rendered the man insane at the moment of the crime; the truth of the defense can be tested by direct experiment; alcohol can be given to the prisoner, and the nature of his reaction ascertained. If he show an insane or abnormal reaction, an extenuating circumstance has been established. Further psychological testing may show that probably he drank because he was mad, besides being mad because he was drunk.

But this method of psychiatry has narrow limits. We cannot measure the disease process when we do not know the person's normal. We need a certain mental capacity even for the tests. The measurements afford little more than a standard by which to judge improvement.

Knauer and Maloney have endeavored to carry forward this method of investigation. They estimated each other's mental capacity under normal conditions, and then the average mental capacity during artificially induced hallucinatory and delusional states. Alcohol was not used to induce the hallucination because the intoxication was too transient. Morphine induced too great blunting of consciousness. A relatively unknown alkaloid, mescalin, was employed. The normal mental reactions of K. and M. together with all their possible variations were recorded daily for several weeks. Then K. injected M. and studied him for days till the effect passed off. Then M. injected K. Each made four experiments on the other. Then ten doctors successively volunteered and finally six laymen.

The principal effects were hallucinations of vision. Gorgeously colored scenes of marvelous content, and of curiously associated sequence passed almost without ceasing before the eyes. Pictures, palaces, churches, statues, armies of grotesque dolls, animals, etc., rolled past in an incessant panorama of wonderful color. Usually the critique remained, the subject knew the pictures were not real. But sometimes, as in one case, of disturbingly real were the delusions that the subject had to be restrained from attempting violence upon the French soldiers whom he saw advancing and threatening. Delusions of hearing were rarer and less pronounced. The most curious delusions were those of muscular sense. Limbs apparently disappeared. The body was felt to be cut into separate halves. The head seemed as if replaced by a ground glass screen. The combination of visual and muscular sense delusions produced strange reactions. One person who felt and saw himself to be in dissociated sections tried to dance himself together again.

Among the sixteen persons tested, insanity was present in the immediate relatives of three. The variations of the reactions of these tainted persons was extraordinarily interesting, and gave rise to the hope that further work in this direction might enable physicians to test the offspring of the neuropathic families and classify them according to their mental stability. We would then have an index to the normal, a guide to the abnormal, and a new test of Mendel's law. There is no one so soundly balanced that adequate mental stress cannot unhinge. There are few so weakly ordered that adequate protection cannot safeguard from passing across the dread borderland. If mental stability could be experimentally ascertained, if we could group people, according as average stress means potential lunacy to them or not, and if we could wisely order the education and environment of the easily deranged a great part of the burden of insanity might be lifted from the drooping shoulders of humanity.

*Reproduced from the *Medical Record*.

Our Commerce and Its Regulation

By F. I. Kent

[While insisting on an entirely neutral attitude with regard to the social questions raised in the article here reproduced from the Banker's Monthly, the Editor of the Scientific American *takes pleasure in laying before the readers of the* Scientific American Supplement *the following excellent presentation of a prominent banker's views.*—Ed.]

During the last hundred years the world's population has increased close to one thousand millions, or about 140 per cent. During the same period the world's trade has increased about 1,800 per cent and it is estimated reached a total of $27,000,000,000 in 1905, of which over 10 per cent represented the foreign trade of the United States. These figures do not include the internal trade of any of the nations. The countries having the largest foreign trade are those in which the great modern conveniences of living abound. Science and trade have made it possible to feed one thousand million more mouths to-day with greater certainty than the lesser number could be fed 100 years ago. They have reduced the proportion of the population which has to work to produce enough food so that all shall be able to live, and have reduced the number of daily hours of work required of each individual. Of the balance of those who labor many manufacture articles of need, convenience or desire, and others distribute the products of all kinds. Twentieth century commerce is adding comfort, ease and luxury to those who live in the fast growing cities and to the rural populations of the world. It is based on great combinations of men and capital which conserve energy, direct it carefully, develop mechanical and scientific genius and store and distribute commodities so that there is stability of labor and of life.

FAIRNESS AT TIMES SEEMS IMPOSSIBLE.

Fairness to all in the development of commerce is seemingly impossible. Human nature and the imperfect judgment of men stand in the way, but the requirements of the multitude ever tend toward betterment and proper regulation always follows increased power. It must not be forgotten that right action under the conditions of yesterday may be wrong action to-day, that the wonderful commercial machinery of the present has been brought about through the foresight of men who comprehended and risked while others were blind and overcautious, that such individuals, while properly having to submit to certain control that developments have now made necessary, are none the less benefactors of the nation, and that they deserve commendation and not condemnation. We must remember that many of the laws controlling them to-day were unnecessary and nonexistent yesterday. Laws of anticipation choke a nation's growth, but laws of regulation if based on science and development, and not on envy or prejudice, may add to its strength.

AS POPULATION INCREASES, DENSITY GROWS.

As the population has increased and its density has grown greater, it has become necessary, in order to make it possible to meet the needs of the people, to multiply the division of labor and to increase the size of capital organizations of all kinds. It is only by means of system that speed can be acquired in delivery of goods, and the consumption of our population has become so vast that great efficiency and great speed in handling commodities are necessary in order to prevent starvation. A slight stoppage in machinery of trade inevitably brings suffering to a part of the population. This has been shown most effectively in England since the strike of the coal miners. The evolution from separate shops to great organizations has been brought about because of necessity.

DESIRE FOR PROFIT ONE OF MOVING FORCES.

The desire for profit is one of the moving forces which induces progress. Such desire is uppermost in the thought of every human being. It may not be expressed in an endeavor to get dollars, but instead may show itself in its direct aim for the power that it is supposed dollars will buy. This desire could be exerted if there were not a dollar in the world, but money, which is nothing other than a medium of exchange, has had to bear the ignominy of the selfish desire for profit, when in reality it has nothing to do with it. To some individuals the desire for profit is an anxiety to raise themselves to the detriment of all others. Again, it is represented in the wish to improve the conditions of all people.

There is an inherent sense of right imbedded in the human heart, which makes individuals realize that fair profit for all is not only the correct but the better way. If left to itself, the normal human mind would develop naturally along lines which would mean increased satisfaction, with every betterment of condition. On the other hand, when a portion of the people are willing to obtain their profit through a development of the baser nature of humanity, improvement in individual conditions may breed dissatisfaction and dissension. The man who yesterday was living without most of the modern conveniences has been taught by the portion of our community, who might legitimately be called the mind poisoners, to judge of his present condition, which may be a great advance over his past, not in relation to his own previous mode of living but in relation to that of others who may be better off. On this account the forms of evolution which have bettered the condition of the individual are not appreciated, but are decried, because they have also bettered the condition of other individuals.

PART PLAYED BY THE NEWS AGENCIES.

The old scandal monger of the village, who used to cause such unhappiness to his neighbors, has grown and been consolidated into vast news distributing agencies which cause the same distrust and dissension among our larger communities that prevailed in the smaller ones. This growth of the mind poisoning trust is something that must be recognized. It is parasitical and feeds upon human errors that will inevitably arise as the needs of humanity are met. It is not contented to allow evolution to proceed in an orderly manner, through the elimination of errors as rapidly as they assume proportions which make it essential for the good of the people, but instead endeavors to tear down the good with the bad, and lives upon the success of its neighbors by appealing to the baser attributes of man.

VALUE OF COMMERCIAL ORGANIZATION.

This development must be recognized and considered before we can fairly judge of the value of the various commercial and business organizations which have made possible our marvelous growth. It has just as important a bearing as the increase in commerce, if we would properly test the efficacy of our modern institutions. Our immediate future growth and success will depend largely upon what proportion of our population is able to consider these two matters fairly and justly. No one can deny the fact that labor to-day is better paid, has shorter hours, and is surrounded by greater comforts and luxuries than ever in the past.

It is also true that the prices of some articles are higher, so that the dollars will not buy as much, but after all other reasons for this have been given their due, there still remains the fact that one cause of the higher prices is the consumption of the articles in question by a larger proportion of the population, which has only become possible because of the better conditions already referred to. That this improvement in condition is true does not mean that we should be satisfied with the present, neither does it mean that we should endeavor to destroy the power which has brought it about. Instead we should study the conditions with an open mind, with the idea of continuing those things which have proved successful and eliminating others which have been found to hamper progress, or which may have been valuable features in the past but that have outgrown their usefulness.

HIGH COST OF LIVING FOSTERS DISCONTENT.

High cost of living waters the seeds of discontent and encourages legislative investigations and indiscriminate criticism, but every individual who is endeavoring to improve his own position is living in the same glass house and is equally responsible for his share of the seeming trouble. Increase in prices is repugnant to everyone, in so far as it has to do with the things which he purchases. On the other hand, no man nor set of men stops to consider this matter in connection with anything that they may be personally depending upon for their livelihood. The business man while objecting to high prices on the commodities which he buys for his home, strives to make himself better able to purchase by getting more out of his own line.

VALUE OF GREATER EFFICIENCY.

Whenever he endeavors to do this through the obtaining of greater efficiency in production or distribution, it works to the advantage of all concerned, but where it goes into increased cost of the article in which he is interested, it means higher prices for some one else to pay on this particular commodity. When the men in a labor union feel the effect of the higher prices of things in general they strike for higher wages, in order to meet them, and demand all that they can get without regard to whether it forces up the price of the article they are helping to manufacture. All this is perfectly natural, but leads to the conclusion that regulation of our commerce, which is in reality the regulation of the means which makes our commerce possible, should not be based on the action of men as individuals, but upon the systems under which they work, and that the intent should be not to disrupt this, that and the other branch of business, but to bring them all in proper relation to each other.

FARMER WANTS HIGH PRICES FOR HIS PRODUCTS.

The farmers want high prices for wheat, corn, cattle, cotton and other commodities which they raise, and low prices for the same and other articles in a manufactured state. The manufacturing interests wish the opposite condition to prevail, and this of course includes the majority of our laboring population. The mind poisoning trust plays one against the other with satisfaction only to itself. This, then, is the first great trust which should be investigated, for it is at the bottom of most of the discontent existing in the world to-day. As the masses have come out from under the cloud of ignorance in which they have been enveloped, they have been led by this great octopus. Their eyes have been opened more by falsehood than by truth, but as their education progresses and they begin to see the tremendous price which they are forced to pay through the constant turmoil of business brought about by their acceptance of vicious teachings, the conditions are going to improve and regulation will go forward in a more scientific and unbiased manner. It is needful, therefore, if we would take the premier position in the development of commerce with its resultant benefits to our people, that our lawmakers begin the study of the system of the mind poisoning trust immediately, with a view of bringing about its dissolution.

SYSTEM IS AT FAULT.

Investigation of this trust should not be made a personal matter any more than in the case of any other. It is more the system itself that is at fault than the men who are in it, and the system is the result of the ignorance and action of the people themselves. The individuals represented by the reporters, editors, writers, public speakers and others have been working under a pressure of public demand, and they have often been led on through necessity to do things entirely foreign to their wishes. Constant repetition of dishonest writing and speaking leads to self-hypotism, and the wrong is forgotten in striving for a livelihood. The system, therefore, should be changed in such manner as to make it dangerous for that portion of the population which gives up its life to writing and speaking to knowingly or even carelessly distort the truth in order to play upon the human passions. If the work is undertaken in a scientific manner without permitting any personalities to enter into it there is no doubt but that the majority of those who are now servants of the system would be glad to do their utmost to put their life work upon an honorable basis.

PROBLEM IS A DIFFICULT ONE.

This is undoubtedly the most difficult of the problems which the world faces to-day, for the right of free speech must be protected, and at the same time license must be prohibited. It is a problem worthy of the best efforts of our lawmakers, and if satisfactorily solved they would be among the principal gainers. It would leave them more free to act as their best judgment dictated for the benefit of the country which they are chosen to govern, and would make the carrying out honorably of their oath of office a pleasure instead of a hardship. It would serve as well to simplify the regulations of all other public interests, and would be the first great step toward the real enlightenment of our people, and would lead inevitably toward contentment and happiness. This, then, is our one great problem which needs solving above all others. Business men of themselves, for their own profit and protection, are constantly improving the conditions under which commerce is carried on. As soon as a wrong method of conducting business develops to the point where it becomes a menace the customs of business change to meet it, and the public is protected before legislation is undertaken.

TRADE FOLLOWS LINE OF LEAST RESISTANCE.

The commerce of the future is going to follow the lines of least resistance and is going to change as time goes on until every country produces that which it is best able to produce, taking into consideration its natural resources and the mental developments of its people. Every line of business is constantly working toward a condition where it may be carried on at a minimum, natural expense. This phenomenon may be noted in the thousands of removals and liquidations of factories. In some cases where a town has been built up entirely on the production of some one commodity, something different has taken its place when it has developed that the article which it manufactured could be more cheaply made elsewhere. This is one of the evidences of evolution in business, and exactly as it is true in a small way in the case of towns and cities in the same country, so it is true between the different countries of the world.

WILL ELIMINATE WASTEFUL COMPETITION.

A time is surely coming when certain kinds of wasteful competition will be practically eliminated and will be reflected in a world's trade of tremendous proportions. Its regulations will be more confined to the natural laws governing production and distribution than by man-made laws, the majority of which will become obsolete when man has learned to properly control public utterance of all kinds. The world's trade will then represent a fair exchange of commodities and their greatest possible distribution among the peoples of the earth, and we in the United States of America, with our diversified resources and composite mentality, should lead all the nations in the march toward prosperity and commercial peace.

Preserving Paintings With Nitrogen.—To prevent the gradual destruction or paintings due primarily to oxidation of the varnish and colors, Carl Mussbeck of Munich, Germany, proposes to incase the canvasses of great artists in a case containing nitrogen gas.

Bird's Eye View Showing Site and Buildings of the Panama Exposition as They Will Appear on Completion.

The Panama-Pacific International Exposition

A World Congress

THE men in charge of the International Panama-Pacific Exposition, which is to be opened in 1915 in San Francisco, are hard at work. Their task is huge.

It is not the commercial and industrial side of the exposition which will predominate. Past expositions have shown that these international gatherings offer an excellent opportunity for enabling the world's great men, the men who have a broad grasp of public affairs to give their views at a time when their messages are most apt to be acted upon. One of the features of the San Francisco exposition will, therefore, be a World Congress, a Congress which will discuss at length and which will formulate doctrines for the guidance of mankind. A confederation of nations of the earth is being thought of in this connection.

The plan formulated for a World Congress depends for its success upon the selection as delegates of men who are not merely able in their respective fields, but of those who possess sincerity of purpose and a broad comprehension of the problem of nations and societies. Such a congress would be able to at least strongly influence the right solution of the more important problems of the world. World questions, debated by a body of men such as that contemplated, should reach conclusions that would command respect.

On its more material side the exposition will follow the lines of similar expositions in the past. Eighteen States have already selected sites for the exhibits, and as many more have either appropriated money for a State exhibit or have appointed commissions to arrange for their participation. The State of New York has appropriated three quarters of a million dollars for its representation, and Pennsylvania is expected to equal if not exceed this sum. All the Pacific States have appropriated sums for participation on the largest scale possible. The exposition of State resources alone, not to mention the wonderful building and exhibition plans of the State of California itself, will be worth traveling far to see.

The Commission appointed by President Taft to visit foreign countries and to extend the Nation's invitation to participate in this celebration has completed its work. France has accepted and undoubtedly all the European powers will take part. In addition, there will be larger representations from South American and Central American republics, Japan, China and Australia, than seen before, and all interested in changes in trade routes through the opening of the Canal.

Belgian Gun-mountings of New Design

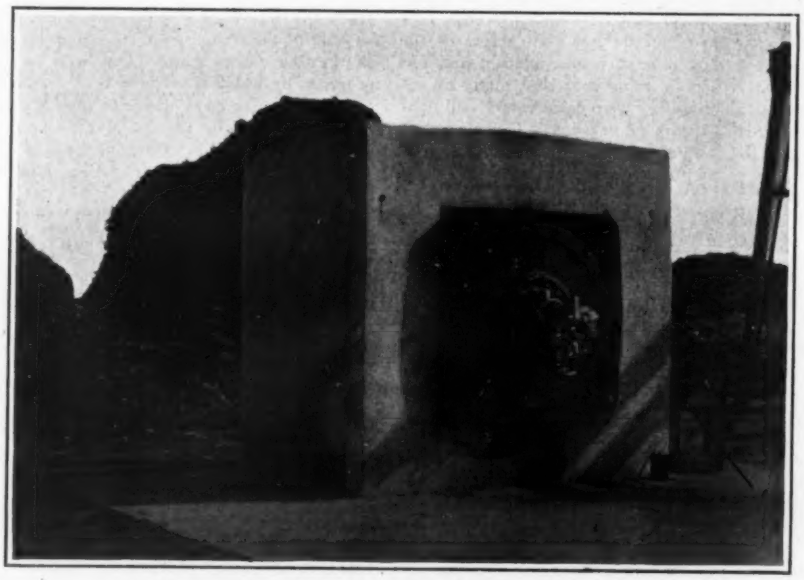
SOME most interesting Belgian guns on embrasure mountings with complete obturation may be noted in the accompanying illustrations, these quick-firing guns being designed for the new defenses at Antwerp. The two models of quick-firing guns adopted by the Minister of War in Belgium are of 2.24 inches and 2.95 inches caliber. The old guns left the embrasure open and were only intended to sweep the outworks of fortifications while these new models have far greater power, and also close up the embrasure completely. The term "complete obturation" refers not to the interior mechanism of the gun, but to the fact that it seals up the embrasure in this way.

The breech mechanism consists of an eccentric breech screw, made larger in diameter than the cartridge chamber and having a hole bored down it to one side of the center. If the screw be given half a turn, this hole will coincide with the bore, if it be turned back again, the solid part of the screw will come opposite the bore, and so close the breech.

It is held that this action may be quickly manipulated, and being all inclosed, is not liable to damage. When the breech is open the hole in the breech screw is in prolongation of the bore of the gun, and the shell and cartridge are inserted through it. The front face of the breech screw has two inclined planes, one which drives the charge home as the breech block turns round; the other, in the inverse motion of the breech screw, bears against the extractor. During the first movement of rotation, the cartridge case is set in motion as usual at the close of the movement, the extractor is sharply jerked against a projection at the end of the inclined plane, and automatically ejects the cartridge case.

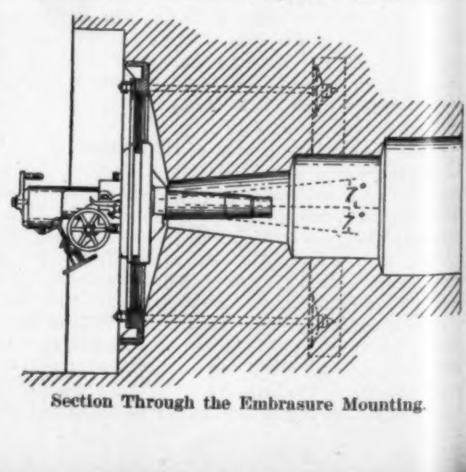
The recoil is checked in the case of the 2.24-inch gun by the elasticity of three vertical metallic disks adjoining one another; they support a large cradle ring which in its turn carries the cradle with its vertical trunnions, only one of which can be seen in the plate. These disks naturally admit of only a very slight recoil; but it is found to be sufficient to break the shock on the concrete walls and the bolts by which the gun and carriage are held in position. The 2.95-inch gun has the ordinary hydraulic buffer for checking the recoil, and two springs to bring the gun back into the firing position.

The embrasure is completely sealed up by a plate which fits closely around the gun, and close up against the wall of the embrasure. The gun crew are entirely sheltered from bullets and bursting shells, and are not troubled by gases escaping either from their own guns or from hostile shells bursting near them. In the



Belgian Gun Mounted in a Concrete Block for Testing Purposes.

Breech Mechanism of the 2.24-inch Gun.



Section Through the Embrasure Mounting.

trenches of fortification, where smoke and gases accumulate near the embrasure, and have a tendency to penetrate to the interior—especially if the wind is blowing down the range, or if there is a fog—these open embrasures soon become untenable. Complete obturation of them is therefore an immense advantage.

Two men firing with one of these guns before a judging committee at Houthalem at a range of 130 yards, fired 20 rounds in 37 seconds and obtained all hits within a rectangle of 10 by 8 inches. The length of bore of the gun of 2.24 inches is 4.9 feet, while that of the 2.95-inch caliber gun is 4.72 feet, and the total length of the guns about 5½ feet. There are 24 grooves, with a width of 0.22 inch and a depth of 0.0118 inch for the 2.24-inch caliber gun the weight of the latter being 510 pounds and of the larger gun 630 pounds. The weights of the common shells are 6 pounds and 14.3 pounds for these guns, the case shot weighing 8.2 pounds for the 2.24-inch caliber gun. In each case the muzzle velocity of shell is 1,412 foot-seconds, while the weight of the fixed charge for the larger gun is 14.4 pounds.

The Use of Reactance in Transformers*

Variable Ratio of Transformation Secured Without Separate Coil

By W. S. Moody

UNTIL recently, reactance in transformers was considered only as an objectionable characteristic. To this there was one minor exception, which will be referred to later on, in connection with transformers to

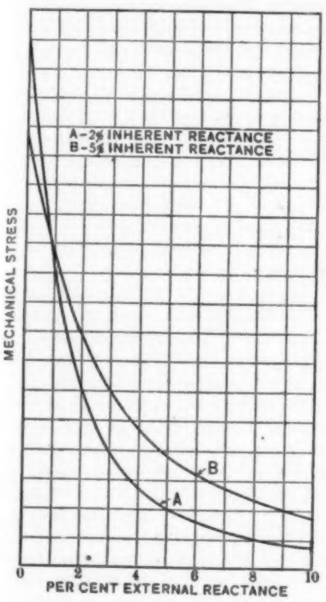


Fig. 1.—Effect of External Reactance on Mechanical Forces in Transformers.

furnish constant current for arc lighting; but in general, because of its detrimental effect on regulation, reactance in transformers has been considered something to be avoided, and the more it was avoided the better was the transformer supposed to be fitted to its use.

Recently, however, in connection with the use of larger units in generating stations, and higher voltages in transmission lines, reactance in other parts of electrical installations has become less and less, until a short circuit in such a system may result in such a tremendous flow of current, that some means of limiting the possible current rush through the system has become imperative. The most natural remedy is to replace in the system, by the transformer, some of the reactance that has been taken out.

Reactance has commonly been used as a means of obtaining a variable ratio of transformation between the source of supply and the collector rings of synchronous converters, but when more than 3 or 4 per cent reactance is desired for this purpose, it has been customary to use separate reactance coils between the transformers and the converter. A very satisfactory method of obtaining as high as 15 to 20 per cent reactance for this purpose in the transformer itself, has been recently developed.

It is the object of this paper to discuss in a general way how reactance can be introduced into transformers for the purposes mentioned above, to point out some of the difficulties and limitations which are met in obtaining the desired results, and to show how effectively some of the problems connected therewith have been solved.

As all know, a transformer would have no reactance when under load if all the lines of force created by its primary threaded through the secondary, and if all the

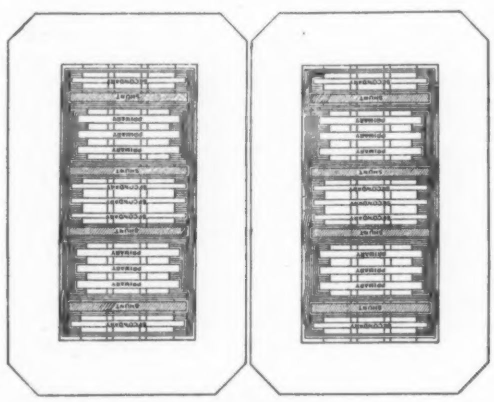


Fig. 2.—Diagram of Shell Type High-resistance Transformer.

lines linking the secondary also linked the primary. Such a complete interlocking of the primary and secondary fluxes is, of course, impossible, a portion of the fluxes always passing through the spaces between the primary and secondary coils.

The percentage of the total flux that links with the primary but does not link with the secondary coil, plus that which links with the secondary but does not link with the primary, is the per cent of reactance of the transformer. That is, when 99 per cent of the primary flux cuts both primary and secondary, the transformer is said to have 1 per cent reactance, and when 90 per cent, only, cuts both primary and secondary, it has 10 per cent reactance.

Calculations for reactance are made by an equation of the form,

$$\text{Reactance Volts} = \frac{(\text{Turns})^2 \times \text{Current} \times \text{Area of leakage path}}{\text{Length of leakage path} \times (\text{No. of groups})^2} \times \text{a constant} \qquad (1)$$

From this formula, it is evident that reactance for a given size of transformer may be decreased,

a. By decreasing the total number of turns in primary and secondary.

b. By decreasing the length of turn, with a corresponding increase in the flux density in the core, or by decreasing the distance between primary and secondary windings.

c. By increasing the dimensions of the windings in the direction in which the leakage flux passes through the wire space.

d. By increasing the number of groups of intermixed primaries and secondaries, the number of turns in each group being correspondingly reduced.

So much effort has been put forth in designing transformers of the lowest possible reactance consistent with reasonable expense in the matter of insulation and efficient proportioning of the various parts, that

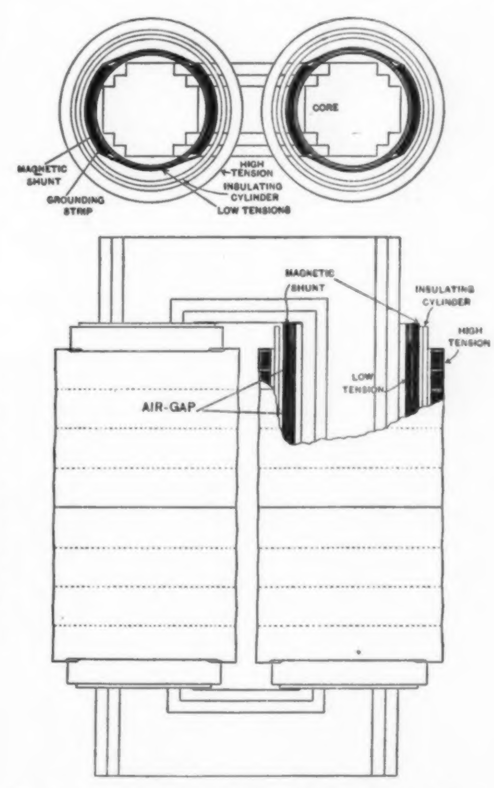


Fig. 3.—Diagram of Core Type High-resistance Transformer.

one would naturally think that if low reactance was not desired, it would be a much easier problem to make a transformer.

Several difficulties are met, however, in the design of transformers with high reactance, principal among which are an extra loss in the conductors due to eddy currents, an increase in mechanical strains under overloads, and difficulties in multiplying different sections of the windings. Some of the leakage flux between the primary and secondary windings must pass through the conductors of the windings themselves, resulting in an inequality of the e.m.fs. generated in different parts of the same conductor. This gives a distorted distribution of current, producing a copper loss, in addition to the calculated I^2R loss, which is roughly proportional to the square of the density of the leakage flux, and to the square of the width of the conductor in a direc-

Fig. 4.—Large Concrete Core Current-limiting Reactance.

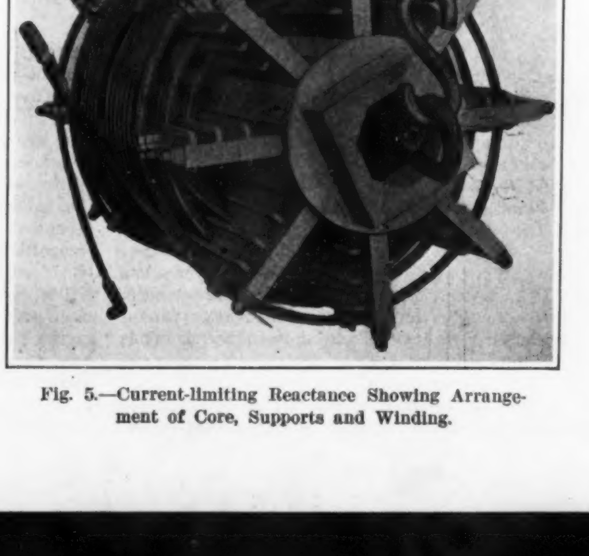


Fig. 5.—Current-limiting Reactance Showing Arrangement of Core, Supports and Winding.

tion at right angles to the leakage field. Unless the width of the conductors is small, therefore, high densities of leakage flux are not permissible, on account of the resulting abnormal copper loss, and the corresponding increase in heating, and decrease in efficiency.

Perhaps the first use of high reactance in transformers was that referred to above, to obtain in the secondary, constant current rather than constant potential for purposes of arc lighting. Here, however, not a constant reactance, but a variable one was needed. High reactance was here obtained without high densities in the leakage flux, by providing a large cross sectional area of the leakage field rather than many turns; and since the conductors were not large, no especial difficulty was experienced with eddy currents. The increased reactance for partial load conditions in these transformers is obtained, by moving the primary farther and farther away from the secondary, so that the leakage flux is increased by increasing the area of cross section of its field, the density remaining constant.

This method of obtaining high reactance is very expensive because of the great length of core that is necessary to surround this idle space, in addition to surrounding the copper and insulation and is prohibitive in large units. The reactance that can be obtained economically, without a density of leakage flux which is not too high from the standpoint of eddy current loss, varies with the voltage of the transformer, for the higher the voltage the greater the distance that must necessarily exist between primary and secondary windings for insulation purposes, and therefore the greater the amount of flux that can be carried through this space without serious eddies in the copper. Thus it may be as easy to make a transformer with 10 per cent reactance when wound for 100,000 volts as for 5 per cent reactance when wound for 25,000 volts, due to the broader path that exists for the reactive flux in the high voltage design.

As a general proposition, it may be said that it is usually impractical to get more than 8 per cent reactance in 60-cycle transformers without undue eddy current losses, and that the allowable maximum would be considerably less than this in low-voltage designs. For lower frequency, higher reactance may be practical, since eddy current losses are less at a given density.

It has recently become customary to specify that the transformer must not have less than, say 5 per cent reactance, for the protection of transformers, switches generators, and in fact all parts of the system against the high mechanical stresses due to excessive currents. It is not always appreciated, however, that limiting the current in this way, while protecting other apparatus, does not necessarily make the transformer any safer to withstand overload conditions.

Calculations for the mechanical stresses in the transformer may be made by the equation,

$$\text{Mechanical stress} = \frac{(\text{Turns})^2 \times (\text{Current})^2}{(\text{Length of leakage path})^2 \times (\text{Number of groups})^2} \times \text{a constant} \qquad (2)$$

where the groups are all alike; or where the groups are not alike,

$$\text{Mechanical stress} = \frac{(\text{Turns})^2 \times (\text{Currents})^2}{(\text{Length of leakage path})^2} \times \text{a constant} \qquad (3)$$

where the turns considered are not the total of the transformer, but the turns in that group which has the maximum number.

From the above equations, it may be seen that when high reactance is obtained by massing the turns in a small number of groups, the "turns" factor of the expression for mechanical stress is increased, though the "current" factor at short circuit is reduced. If the groups are not kept equal to each other, the maximum stress, which occurs in the maximum group, and which produces the forces that are felt by the core and coil supports, is likely to be actually greater under short circuit conditions for a high reactance transformer than for a low reactance one.

With equal numbers of turns in all the groups, the forces will be greater for the low reactance transformer than for the high reactance one at absolute short circuit with full voltage maintained on the primary terminals, although not enough greater to make a very serious difference in any case where the supports are designed to supply a proper factor of safety for the high reactance transformer. Moreover, with a definite fixed current flowing, the force will be much smaller for the low reactance transformer than for the high reactance one, and with a comparatively small external impedance, in addition to the impedance of the transformer, the force due to short circuit becomes less for the low reactance transformer than for the high reactance one.

From the above it will be seen that very little is to be gained from the standpoint of safety to the transformer by the introduction of high reactance within the transformer itself. It is true that this would protect other parts of the system, but the additional reactance would be equally as effective for this purpose outside of the transformer as inside of it.

This is illustrated by Fig. 1, which shows the mechanical stresses under short circuit conditions, in a transformer designed for 2 per cent reactance and in the same transformer when redesigned for 5 per cent reactance. It is assumed that constant voltage is maintained at the primary terminals. With normal current only flowing, the mechanical stresses in the high reactance design are higher than in the low reactance design, but when short circuit occurs at the secondary terminals, the stress is higher in the low reactance design. This is shown on the curve for zero external reactance. With the addition of about 1 per cent external reactance, the curves cross and with further increase in external reactance, the high reactance transformer is subjected to the greatest strains.

With 3 per cent external reactance added to the low reactance design and none to the high reactance design, thus making the total in both cases 5 per cent, the stress in the former is only about one fourth as great as that in the latter.

When short circuit occurs at some distance from the transformer, the reactance of the lines adds to the transformer reactance and serves to reduce the stresses on the transformer. In fact, in this case the line resistance also assists, and a smaller value of external reactance will cause the two curves to cross and the stresses in the low reactance design to become less than those in the high reactance design.

The effort to obtain sufficient reactance for current limiting purposes in an auto-transformer is a more difficult problem. These are frequently used for a one-to-two ratio of transformation, as, for instance, in stepping-up the voltage of a 10,000-volt generator to 20,000 volts. Here the auto-transformer has only half the rating of the generator, and the effect of its reactance on the system is only one half that of its own inherent reactance. In some cases where it is necessary to get the equipment in the smallest possible space or keep to the lowest possible costs, it is necessary to be satisfied with what current-limiting reactance can be placed in the system by such an auto-transformer, but an exceedingly rigid design of coil supports then becomes necessary.

When greater amounts of reactance are desired for flexibility in ratio of transformation, as for use with synchronous converters, the result can be obtained by placing a laminated iron structure between primary and secondary in such a way as to form a path for the leakage flux. If this iron path is of such a section as to carry the flux corresponding to the desired reactance without approaching saturation, the copper will be entirely shielded from eddy currents, and the transformer's reactance may be increased almost without limit. It is evident, however, that the use of such a device does not extend the possibility of current-limiting reactance, as the amount of iron that would be necessary to carry the entire flux on short circuit would result in a prohibitive amount of reactance, from a regulation standpoint, at normal loads.

It is interesting to note that this use of an iron path for the reactive flux, as well as the high reactance design in which the flux is entirely within the air space between primary and secondary, was first developed in connection with arc lighting apparatus, where transformers with a fixed high reactance were used to obtain regulation characteristics approaching constant current. The proportioning of these flux shunts for transformers with regulating reactance is an interesting and not altogether easy problem, and it may be of sufficient interest, in view of the fact that it has been so recently reduced to practice, to be worthy of comment here.

Evidently there must be as many shunts as there are spaces between primary and secondary groups. Evidently, also, the section of these shunts must bear the same relation to the section of the core of the transformer as the reactance voltage bears to the full voltage of the transformer. This on the assumption that the density in the shunt at full load is to be the same as the normal density in the core at normal voltage. However, it is usually the case that if a straight line characteristic is to be obtained in the reactance, say, up to 50 per cent overload, the section of each of these shunts must be somewhat larger than this; that is, for 15 per cent reactance the section of the shunt will have to be perhaps 20 per cent of the section of the transformer core.

Again, it is necessary to have air gaps in this circuit: First, because a straight line characteristic cannot be obtained with any magnetic circuit that is a closed iron circuit; and second, because in any group of ampere turns that would be practical, a sufficient magnetomotive force would be obtained to oversaturate the shunt circuit at full load if there were only the reluctance of the iron circuit to limit the flux. It should be noted that the loss in these shunts is not a constant one like core loss, but various with the load; consequently, it affects efficiency as if it were a copper loss. However, the loss in the shunts is small as their weight is very small compared with the weight of the core.

Figs. 2 and 3 illustrate the manner in which these flux shunts are placed in core type and shell type designs, respectively.

Figs. 4 and 5 show the general appearance of the concrete core external reactances which have been developed and successfully used in large power systems to limit the flow of current at short circuit.

Modern White Pigments*

Their Manufacture and Properties

By C. A. Klein

The subject of paints has of recent years become one on which public attention has been focussed, largely in consequence of the incidence of lead poisoning which is observed among those engaged in the manufacture and use of paints containing a lead base, and this has been an important factor in the recent history of the development of the paint industry. It is only within the last few years that white lead has encountered any serious opposition, although substitutes of various kinds have been offered for many years. The progress of the present substitutes is the direct outcome of the application of experience gained after extensive and costly experiments. In the early days it was soon discovered that substitutes must have properties other than dazzling whiteness and chemical purity, and further that the necessary properties were not easily attained. The patent records cover an enormous range of white substances, few of which have proved of any practical value. It is only proposed to deal with white pigments in this article, as either alone or as basis for colored paints, such pigments constitute the greatest portion of the paint now used.

For years a keenly conducted controversy has been waged with regard to the respective merits and demerits of white lead and its substitutes, and the object of the writer is to give a short account of the products which at the present time are of commercial importance.

The controversy can only be settled after careful and organized investigation, and at the outset demands some definite agreement as to a basis of comparison for the different purposes for which paint is used, e. g., indoor, outdoor, exposure to sea air, etc. If such an agreement was made it would go far toward a settlement and there would be less argument as to the exact meaning of such expressions as "covering power," etc., which at the present time have meanings which vary considerably. Comparison can only be made on broad lines, and the basis must be so comprehensive as to merit the term "painting value," in which all the factors which determine the provision of a well decorated and protected surface, have received due recognition, e. g., cost of materials, cost of application, life of paint, cost of repainting, etc.

The failure of many of the earlier substitutes has been responsible for a marked conservative attitude in the painter, which is not conducive to the necessary co-operation of theory and practice, but this barrier is slowly being removed and more desire to try new materials is apparent.

At the present time it cannot be maintained that

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any single known pigment is ideal for all purposes, and the possible preparation of such a product appears doubtful. It is not improbable that the solution of the problem lies in the proper selection of the pigment or mixture of pigments whose properties are most desirable for the proposed work.

It has been clearly shown that the weakness of one pigment can be removed by the addition of other pigments, and that in many cases a mixture is advantageous. The present white pigments now in use in any considerable quantities number only four, viz., white lead, basic lead sulphate, zinc oxide, and lithopone, and the following notes give outlines of the history and manufacture of these four products.

White Lead.—The early history of white lead is of great antiquity, and presents few interesting features from a scientific standpoint, except that the records show that the conversion of metallic lead into carbonate was by means of the acetate, a feature which still holds in all present processes, though it is of interest to note that recently a patent was granted for the use of amino acids, which indicates a desire to depart from the time-honored and effective method.

The Dutch Stack method is the oldest process now adopted, and all other existing processes have been designed with a view to more quickly carrying out by various means the reactions known to take place in the stacks. In the ordinary stack process a period of about ninety days is required for conversion of the metal into carbonate, whereas in some of the newer processes the complete operation occupies less than twelve hours.

Although the actual Dutch Stack process has not been subject to much alteration for many years past, there has within recent years been very considerable advance from a chemical and mechanical standpoint, and much bacteriological work has been carried out with the object of controlling the fermentation of the tan or other waste product used for the production of carbonic acid gas. These advances have doubtless been necessitated by the progress made by the more recent quick processes which have after many reverses been firmly established in various countries.

Of the newer processes, the "Chamber Process," which claims to show the closest mechanical relationship to the stack method, consists in the exposure of thin sheets of lead to artificially-produced carbon dioxide and steam in the presence of acetic acid vapor. The process is used in England and largely in Germany, but curiously has not found application in the United States of America. The product is of excellent color and occupies a recognized position among users. Modifications of the chamber process, where still larger surfaces of metal are exposed, e. g., lead sponge and fiber, have been tried with varying success. In the United States of America processes are in use in which finely-divided lead is oxidized and hydrated and afterward converted into basic carbonate by means of purified boiler flue gases.

A number of processes, termed "wet processes," are the outcome of the method introduced by Thenard in 1801. The Thenard process consisted of the precipitation of white lead from a solution of basic lead acetate, using furnace gases containing from 12 to 17 per cent carbon dioxide. The improvements which have been made in the process deal with the method of obtaining the basic acetate solution, use of pure carbonic acid gas, conversion under pressure, etc., and are of practical importance only.

The Bischof process depends on the conversion of a specially prepared lead hydrate into carbonate, using a definite quantity of normal acetate of lead as catalyst.

Many of the above processes are supplemented by purification methods for the removal of uncorroded lead, lead acetate, and neutral lead carbonate which would adversely affect the product as a paint material.

Precipitation by alkaline carbonates, though often suggested, has not proved to be of practical value; further, as yet, the electrolytic processes have made no progress.

White lead is sold either as a dry powder or ground in oil in the form of paste containing from 6 to 8 per cent of linseed oil. Commercial white lead approximates to the composition $2PbCO_3$, $Pb(OH)_2$, and it is frequently stated that this composition is the most desirable, though there is little to support this conclusion. The exact chemical composition of a pigment is of little or no value in determining its pigment value, and its importance is much overrated, while the physical condition which is the determining factor is frequently ignored.

Chemically there is little difference between the products of the present processes, but physical differences are more common, and the successful working of a white lead process lies in the control of the factors which produce the best physical condition commensurate with a reasonable latitude as regards chemical composition.

The bulk of the white lead sold is pure, but a small quantity of "reduced" white lead finds application. The "reduction" is effected by the use of barytes on a recognized scale, and white lead containing barytes must be marked "reduced." Few cases of fraudulent adulteration take place in England owing to the efforts of manufacturers in this connection.

The specific gravity of white lead is higher than that of any of its substitutes, the figure varies somewhat according to the method of preparation and chemical composition, but 6.5 may be considered an average figure.

Basic Sulphate of Lead or Sublimed Lead.—The use of basic lead sulphate as a paint material was first suggested by Bartlett in 1866, and a process was patented by him in 1870 for its preparation from Galena. The progress made was comparatively slow until within recent years, but now the product has very extensive use in the United States of America, and more recently its manufacture has been introduced into England. The process consists in the furnacing of high grade galena which has received a preliminary jigging and crushing. The furnacing is carried out in a special type of blast furnace, whereby lead sulphide is volatilized and oxidized. The resulting basic sulphate is collected dry in goose-neck condensers and bag filters.

The chemical composition of basic sulphate varies between the compounds (PbO, $PbSO_4$), and (PbO, $2PbSO_4$). The impurities consist of foreign substances either volatilized from the galena or carried over mechanically by the blast. When zinciferous galena is used a notable quantity (about 5 per cent) of zinc is found in the product. The slight creamy color frequently observed is attributed to iron. The product consists of particles of uniform size in an extremely fine state of division.

It is sold dry, or in an oil paste containing about 9 per cent linseed oil. The specific gravity is approximately 6.2.

Zinc Oxide.—The use of zinc oxide as a substitute for white lead was first suggested by Guyton de Morveau about 1780, whose suggestion encouraged Courtois, who had also been engaged on the problem, to undertake its manufacture on a large scale, and in consequence Courtois established businesses in Dijon and Paris. The progress made during the next sixty years was very slow in spite of the support of men of the standing of Fourcroix, Berthollet, and Vauquelin, and it was not until about 1844 that Jean Leclaire commenced the famous campaign which after long-drawn struggles culminated in the French Act of July 20th, 1909, interdicting the use of white lead in all paint work on buildings after 1914 under certain conditions.

Since its early introduction many improvements have been effected in the method of manufacture and quality, with the result that zinc oxide has now very extensive application.

Two types of zinc oxide are marketed, known as "indirect" and "direct," and these are prepared as follows: "Indirect" oxide is prepared from spelter, and is therefore comparatively chemically pure. The process consists of the oxidation by air blast of the zinc vapor obtained by the distillation of zinc from retorts of special construction.

The oxide so produced is passed through a series of cooled pipes, thence to settling chambers. The purity and color of the oxide is determined by the distance it is carried in the settling chamber, and the product is graded by this means. Qualities are branded in seals, e. g., green seal, red seal, etc. This process is used in Europe and to some small extent in Pennsylvania. The oxide is excellent in color and comparatively free of impurities.

The "direct" process, which produces zinc oxide direct from the ore, is of American origin, and was originally due to S. T. Jones, who, in 1850, erected a special furnace for this purpose. The commercial application of the process was established five years later by Wetherill, who had made material improvements on the original scheme.

During the last thirty years the output of this process has increased enormously. Wetherill first applied the process to the New Jersey Franklinite ores. The New Jersey ore is a complex of Franklinite, Willemite, Calcite and occasionally Zincite, having an average zinc content of 25 per cent. Process takes place in three stages, viz.: (1) Removal of sulphur from ore by roasting; (2) magnetic separation and jigging of roasted product; and (3) reduction of zinc oxide in ore to metal with volatilization and subsequent oxidation. The oxide is collected in chambers followed by bag filters.

The product so obtained compares favorably in chemical purity with that obtained by the "indirect" process, but it was found that this was not maintained when western ores were treated. This is due to the different chemical composition of the western ores, which are blendes, and contain sulphur in quantity together with some lead. The roasting of western oxides yields large quantities of sulphur dioxide, and in some cases this is used for the manufacture of sulphuric acid. The subsequent treatment of the roasted ore is similar to that adopted for eastern ore. Lead (as basic sulphate) is present in western oxide up to about 6 per cent. The "direct" process has been applied to European ores, which are somewhat similar in composition to the western ore, and here again the impurities affect the final product, so that European direct oxides almost invariably contain lead, and this is recognized in some Continental specifications. The color of direct oxides, other than New Jersey, is not equal to that of the "indirect" oxides, and great care must be taken to avoid the formation of zinc sulphate in the product, owing to its injurious effect on the paint film.

The product is graded into qualities according to color and lead content, the different grades being distinguished as red seal, green seal, etc. At present there is no generally accepted opinion as to the superiority of one type of oxide over the other, though it is claimed by some that the small quantity of basic lead sulphate present in some "direct" oxides increases the stability of the resulting paint film.

In America so-called "leaded zincs" are prepared by furnacing mixtures of galena and blende. These contain from 20 to 30 per cent of basic lead sulphate, together with 70 to 80 per cent zinc oxide.

Various wet processes (precipitation and electrolytic) have been suggested for the manufacture of zinc oxide, but as yet have not assumed commercial importance.

Zinc oxide is sold either as a dry powder (specific gravity about 5.6) or as an oil paste containing 14 to 20 per cent of linseed oil.

Lithopone.—Lithopone or lithophone are generic names given to a class of pigments of varying composition. The highest grade lithopone contains about 28 per cent zinc sulphide, 70 per cent barium sulphate, 2 per cent zinc oxide, while the lower grades contain less zinc sulphide and more barium sulphate, the reduction usually being effected by mixing the high grade with diluents.

The manufacture of lithopone was first patented by J. B. Orr in 1876, and the product sold as Orr's White Enamel and Charlton White. In 1876, Griffith, and 1879, Griffith and Crawley, were granted patents for improved processes. Since that date very numerous patents have been obtained, generally of little practical value. The manufacture of lithopone, although originally an English process, has not made much headway in England, but on the Continent of Europe the process has assumed huge proportions, doubtless owing to anti-white lead agitations. The U. S. A. production is also considerable.

Products of varying composition (frequently mixtures of lithopone with other white pigments) are sold under fancy trade names, which give no indication as to composition. The term "white zinc" is sometimes wrongly applied to lithopone. Zinc white or white zinc should always be zinc oxide.

Lithopone is prepared by the mutual precipitation of barium sulphate, and zinc sulphide using solutions of barium sulphide and zinc sulphate. Mutual precipitation insures homogenity of product, which is most desired in a paint material.

The solution of zinc sulphate is prepared direct from the ore in Germany, while the American practice is to dissolve spelter or by-products containing zinc. Barium sulphide is prepared from barium sulphate by reduction with carbon in specially constructed furnaces.

The furnace mass is leached with water and the solution so obtained purified. The solutions of barium and zinc must be pure, otherwise precipitation carries down impurities which seriously affect the color.

The precipitate of lithopone is dried and furnaced at high temperature, and is then quenched in cold water, which increases the density and at the same time reduces the oil absorption.

In the operation of calcining, a small portion of the zinc sulphide is converted into oxide. Various additions are made to the furnace charge to minimize this oxidation. The substance added being one which will on volatilization produce an inert atmosphere in the furnace charge and so prevent oxidation. The quenched material is ground in water and dried.

Lithopone is at times curiously sensitive to light; in strong sunlight a painted surface sometimes rapidly becoming grey-black in color. The white color is regained in the absence of light. The cause of this phenomena is not understood, and though many remedies have been suggested, none can claim to be absolutely effective, the change occurring in specially treated products with disconcerting irregularity.

Lithopone is sold as a dry powder, specific gravity about 4.2, or as an oil paste containing from 17 to 18 per cent linseed oil.

Ready-mixed Paints.—The foregoing covers practically all the white pigments in use as bases for oil paints. Many additions are made when ready-mixed paints are prepared, but usually the principal base consists of one or more of the four substances described.

Fig. 1.—Dorry Hardness Machine.

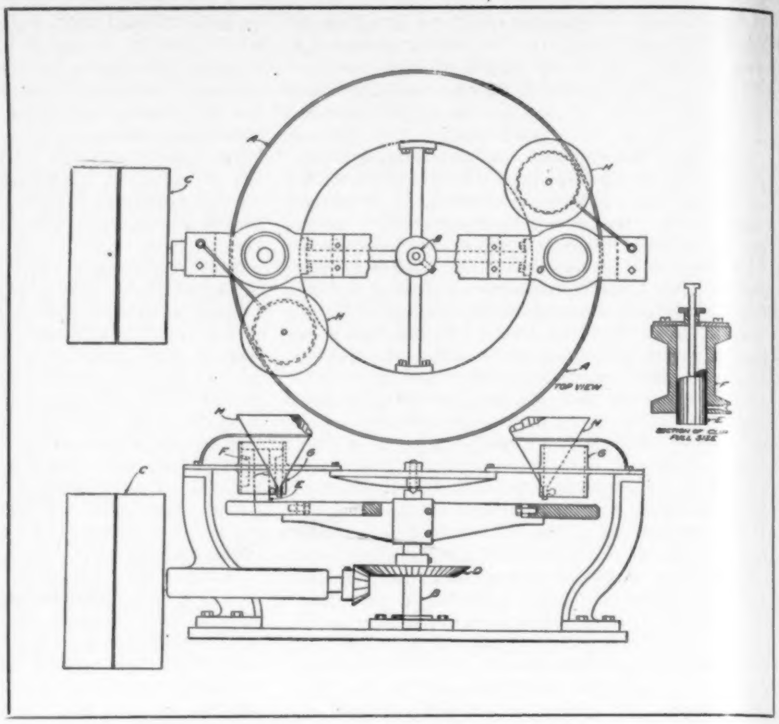

Fig. 2.—Details of Dorry Hardness Machine.

The Physical Testing of Rock for Road Building—I*

The Methods Used and the Results Obtained

By Albert T. Goldbeck and Frank H. Jackson, Jr.

THE study of the physical and chemical properties of road materials by means of laboratory tests has been carried on in a more or less desultory fashion for over 30 years. Quite recently, however, the development of more systematic and greatly improved methods for testing, with a consequent augmented accumulation of data, has given the results obtained a much more practical significance than formerly.

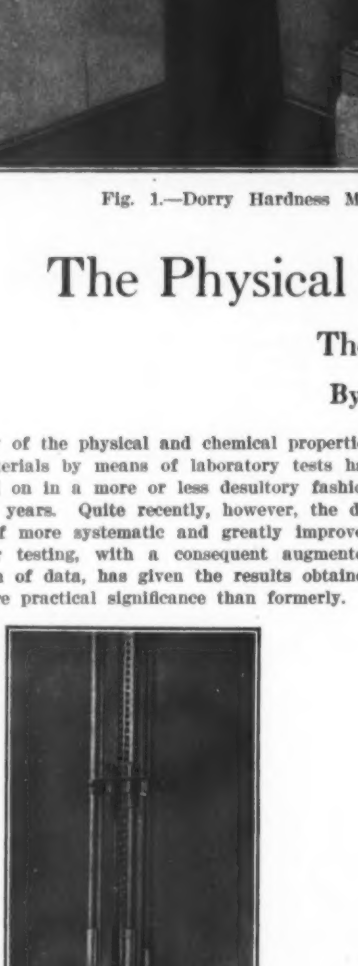

Fig. 3.—Page Impact Testing Machine.

In December, 1900, the United States Government, because of the growing importance of the problem of testing road materials, established a laboratory in the Bureau of Chemistry of the Department of Agriculture, under the direction of Mr. Page. This laboratory was transferred in 1905 to the Office of Public Roads, where its present organization was developed.

The present general interest in the necessity for good road construction has resulted, quite recently, in the establishment of laboratories in many technical institutions, both in this country and abroad, as well as in the various State highway commissions.

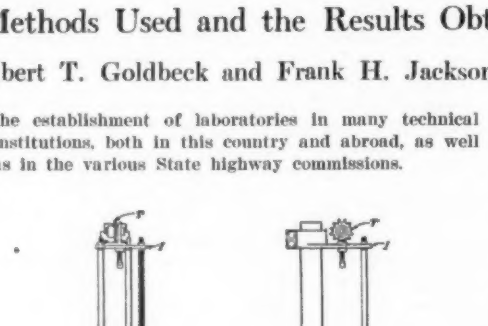

Fig. 4.—Details of Page Impact Testing Machine.

The fact that a large number of samples are submitted for investigation and reported on annually by these laboratories is good evidence of the value of the information received by the road engineer through the agency of laboratory tests on the relative worth of the materials which he proposes to use in road construction, and it is the object of this bulletin to describe these tests as now practiced and to interpret their results.

AGENCIES DESTRUCTIVE OF ROADS.

The surface of a road is subject to deterioration due to the effects of (*a*) mechanical, (*b*) chemical, and (*c*) physical agencies whose disintegrating action may be more or less combated by proper construction and maintenance with carefully selected materials. The individual stones in a macadam road are bound together by finer particles and rock powder, and the ideal condition is that in which there is always just enough dust existing to cement these stones together tightly.

(*a*) *Mechanical Agencies.*—The action of traffic on a road surface is purely mechanical. The severe impact of horses' feet tends to disturb the individual stones by loosening the binding material. At the same

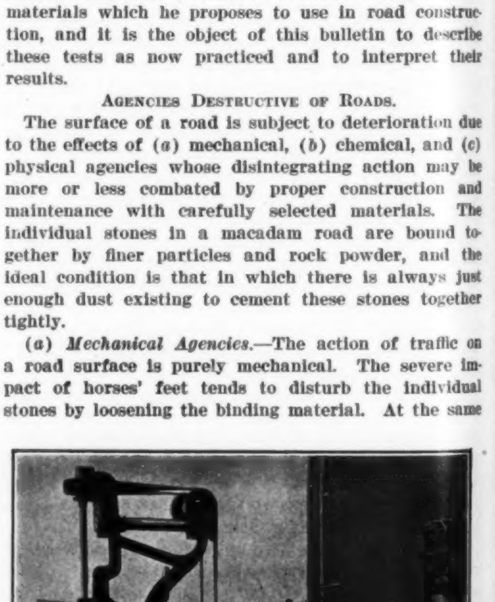

Fig. 5.—Method of Drilling Core from Rock Sample With Diamond Core Drill.

* Office of Public Roads, Bulletin 44.

time the stones are subjected to an abrasive action which grinds away their surfaces. The fine material thus created is partly carried away by the wind and partly washed away by the rain, while part is retained

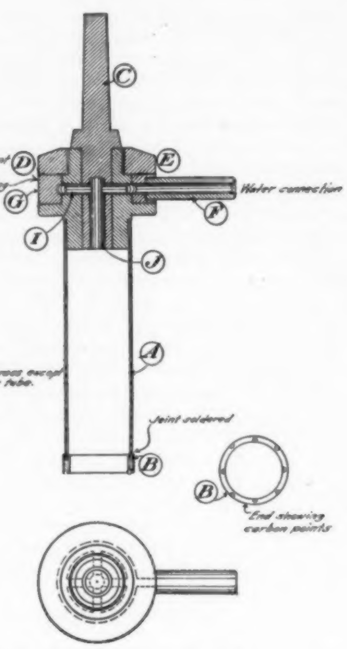

Fig. 6.—Details of Core Drill.

on the road under favorable conditions to form new cementing or binding material. Should there be more fine material formed by abrasion than is carried away by the wind and rain, the road becomes dusty and muddy; whereas if too little fine material is formed to cement the particles of rock together, the road disintegrates because of raveling.

Automobile traffic exerts a severe shearing action on the road surface which loosens the individual stones, but fails to supply, by abrasion, enough additional fine material to compensate for that lost in the clouds of dust raised by this class of traffic. As a consequence, plain macadam construction ravels when subjected to considerable fast moving automobile traffic.

(*b*) *Chemical Agencies.*[1]—Since all rain and surface water contains carbonic acid in amount sufficient to dissolve carbonates of lime and iron, there is some disintegration from this source. The humus acid derived from animal and vegetable decay likewise renders soluble certain of the rock-forming materials containing magnesia, potash, soda, lime, iron, and silica. However, investigations have shown the deterioration of road surfaces from this source to be negligible.

(*c*) *Physical Agencies.*—Although it is probable that rock used in road making is very little affected by the action of frost, the action of repeated freezing and thawing on the body of the road is considerable. This is particularly true in the event of poor drainage, because the absorptive power of the roadbed is in general quite high, even though the absorption of the rocks used is low. The materials loosened up by the heaving action of the frost are carried away, to the detriment of the road, by the mechanical action of wind and rain.

Necessary Physical and Mechanical Qualities of Road Materials.

The action of mechanical agents is by far more severe in causing the destruction of a road than either chemical or physical agents, and the ability of a rock to withstand mechanical destruction is of great influence in judging its value as a road-making material.

A road-building rock must have three very essential characteristics, i. e., it must be (*a*) hard and (*b*) tough, and (*c*) it must have good cementing or binding power.

(*a*) By the hardness of a road material is meant its ability to resist the abrasive action of traffic in causing displacement of the surface particles by friction.

(*b*) The toughness of a rock is a measure of its ability to resist rupture due to the impact of traffic.

(*c*) The cementing or binding power of a rock determines how firmly the individual stones will be cemented together by the rock powder formed through the action of traffic.

Physical Tests of Road Materials.

To determine the above three characteristics essential for a good road material, as well as to investigate other minor physical features, the following tests are made at this office: (1) Hardness; (2) toughness; (3) resistance to wear; (4) cementing value; (5) specific gravity; and (6) absorption.

[1] Logan Waller Page in Report of Mass. Highway Commission, 1900.

Hardness Test.

The test for the hardness of rock, i. e., the resistance of its surface particles to displacement by abrasion, as determined in the Dorry machine, was developed in the French School of Bridges and Roads, and is used with slight modifications at the present day.

Dorry Machine.

The Dorry machine (see Figs. 1 and 2) consists of a circular steel disk *A*, revolving in a horizontal plane about the vertical shaft *B*, which is driven from the pulley *C* by means of the bevel gear *D*. The cylindrical rock core *E*, 25 millimeters in diameter, is cut from a specimen of rock with a diamond core drill, and the test piece is held perpendicularly against a revolving cast-steel disk under a constant pressure of 1,250 grammes, while standard quartz sand, between 30 and 40 mesh, is fed on the disk to act as the abrasive agent. The machine used is arranged to hold two core pieces so that two tests can be run simultaneously. At the end of 1,000 revolutions the loss in weight is determined and the test repeated with the specimen reversed. The average loss in weight computed from the two runs is used in determining the hardness of the rock. In the earlier work the loss in length was determined from measurements taken before and after each run, and the average loss expressed in millimeters per 1,000 revolutions subtracted from 20 was given as representing the hardness of the specimen. The arbitrary constant 20 was selected with a view to giving the results of this test about the same range of variation as the French coefficient of wear described later under the abrasion test. It has been found, however, that the hardest rocks lose only about 2 millimeters per 1,000 revolutions, while some of the softer varieties lose considerably more than 20 millimeters, thus giving rise to negative values in the results of the test. In order to avoid this, the following method of expressing the hardness has been adopted:

$$\text{Hardness} = H = 20 - 1/3\ W,$$

where W = loss in grammes per 1,000 revolutions.

The results of numerous tests which have been made with the above machine will appear in our next issue.

Toughness Test.

As applied to road materials, toughness is understood to mean ability to resist fracture due to impact. To be resistant to the severe pounding action of traffic

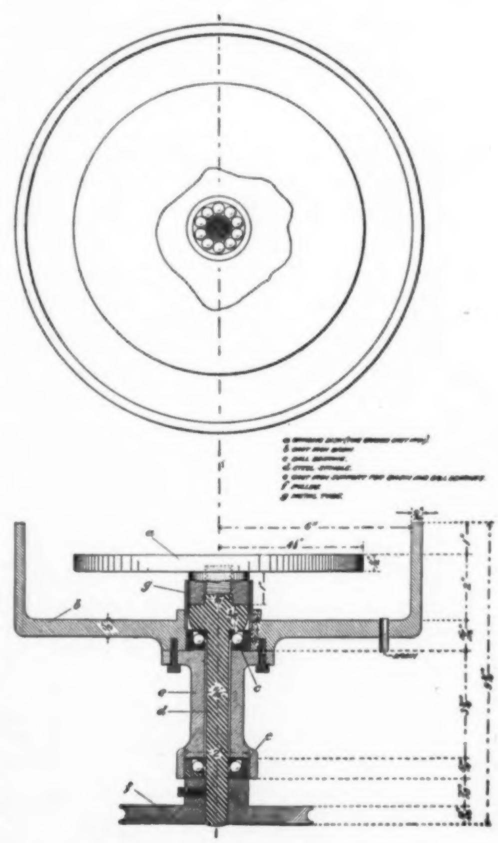

Fig. 8.—Details of Grinding Lap.

on the roadway, road material, it will be recognized, should possess the quality of toughness to a high degree. The method of testing the toughness of rock, as used in its present form, was developed by Logan W. Page.

Page Impact Machine.

The Page impact machine (see Figs. 3 and 4) consists of a 2-kilogramme hammer *N*, which is guided by two vertical rods *J*. The upper end of the hammer has a small cone set in it, which fits snugly into a concentric electromagnet, and this is attached to the lower side of a cross-head *M*, which slides freely on the guide rods *J*. This crosshead is provided with a slot on its rear side through which a sprocket chain *S* passes, and this sprocket chain is supported on the sprocket wheels, which are attached to castings at the top *I* and near the base *H* of the machine. The lower sprocket wheel is directly connected by a worm gear to an electric motor *G*. The sprocket chain is provided with two small lugs *X*, which, when the chain is being driven by the motor, engage a spring bolt attachment which projects inward on either side of the slot on the cross-

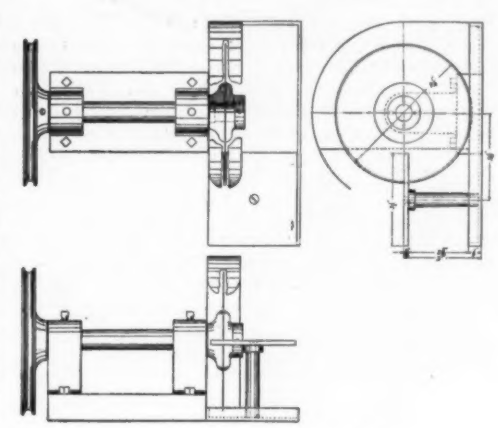

Fig. 7.—Details of Diamond Saw.

head *M*. This raises the crosshead until tripped by a rod projecting downward from an upper crosshead *L*. When this takes place, the crosshead *M*, which holds the electromagnet, falls until it comes in contact with the hammer *N*. The electromagnet is supplied with current from the circuit running the motor. This current is conveyed through two small conducting rods running parallel to the guide rods, both of which are insulated from the rest of the machine. The current passes from one of these conductor rods through a small carbon brush to a make and break attachment on the upper crosshead *L*, thence down one of the guide rods, through the electromagnet, and back to the other conductor rod.

When the crosshead *M* is raised by the lugs on the sprocket chain and the current turned on the magnet, the hammer is lifted until the crosshead *M* comes in contact with the make and break on the crosshead *L*, and thus releases the hammer, which falls, striking a plunger *O*. This plunger is made of armor-piercing steel, with the maximum temper at its lower end, which is spherical in shape. The test piece rests on a counter anvil *W* of hard steel, while the plunger rests on its upper surface, which is tangent to it at its center point.

It will be observed that the blow, as delivered through a spherical-end plunger approximates as nearly as practicable the blows of traffic. Besides this, it has the further advantage of not requiring great exactness in getting the two bearing surfaces of the test piece parallel, as the entire load is applied at one point of the upper surface.

The upper crosshead *L* is raised through any desired height by means of the long, revolving screw *K*, which is geared at its lower end to a dial *Q*, on which the height of the make and break attachment and, therefore the height of the hammer drop may be read directly. By means of the revolving dial and screw the height of the crosshead may be adjusted, by very close approximation, to within one millimeter.

In order to prevent the crosshead *M*, which holds the electromagnet, from striking too hard a blow on the hammer when falling, a dashpot was first used, but it has been found that a few drops of cylinder oil on the lower end of the guide rods completely eliminated this difficulty.

The test consists of a 1-centimeter fall of the hammer for the first blow, and an increased fall of 1 centimeter for each succeeding blow, until failure of the test piece occurs. The number of blows required to cause failure is used to represent the toughness.

The impact test was adopted by the American Society for Testing Materials on August 15th, 1908.

Core Drill.

(For preparing rock core.)

Specimens for the hardness and toughness test are prepared by drilling a core from the sample of each to be tested. The core drill shown in Fig. 6 consists of a steel core tube *A*, carrying at its lower end the brass ring *B*, containing eight carbon points, spaced as shown,

to cut a rock core 25 millimeters in diameter. The core tube is connected at the upper end with the brass casing *DE* through which passes the lower part of the shank *C*.

The water-supply tube *F* is connected directly to the stationary brass ring G, which has a semi-circular section cut in its inner side to fit a similar section in the casing *D*, forming a circular hollow tube, one half of which is stationary and the other half movable with the drill. Four small holes *I*, joining the vertical tube *J*, connect the ring with the inside of the core tube *A*, and the whole forms an arrangement for carrying water from the supply tube *F* to the inside of the revolving drill.

Diamond Saw.

For sawing the cores to the proper length in the preparation of specimens, a diamond saw is used (see Fig. 7). It consists of a steel disk, about 5 inches in diameter by 0.02 of an inch thick, around the circumference of which diamond dust is held in radial slots. This saw is driven by a small electric motor at a speed of 600 revolutions per minute.

Grinding Lap.

In the preparation of the faces of hardness and toughness specimens, a grinding lap, 9 inches in diameter, driven at 400 revolutions per minute, is used. The abrasive agent is finely powdered emery. (See Fig. 8.)

ABRASION TEST.

The abrasion test, as performed in the Deval abrasion machine, tests the hardness as well as the toughness of rock, and much valuable information has been obtained on the wearing qualities of rock since this test was originated in the French School of Bridges and Roads.

Abrasion Machine (Deval Type).

The Deval machine (see Fig. 9) consists essentially of the pulley *A* (or worm gear and motor, direct connected, as used at present) driving the shaft *BB*, upon which are mounted the four cast-iron cylinders *CCCC* in such a way that the axes of the cylinders are inclined at an angle of 30 degree with the axis of rotation. These cylinders are 20 centimeters in diameter and 34 centimeters in depth inside. The shaft is set in the three bearings *DDD* and carries at *E* a commutator ring for operating an electrical revolution counter, which is not shown.

The rock is broken in pieces, as nearly uniform in size as possible, and as nearly 50 pieces as possible constitute a test sample. The total weight of rock in a test is within 10 grammes of 5 kilogrammes. All test pieces are thoroughly dried before weighing. Ten thousand revolutions, at the rate of between 30 and 33 to the minute, constitute a test. Only the percentage of material worn off which will pass through a 0.16 centimeter (1/16 inch) mesh sieve is considered in determining the amount of wear. The amount of wear is expressed either in the per cent of the 5 kilogrammes used in the test, or else the French coefficient, which in more general use, is given, viz:

The coefficient of wear =

$$20 \times \frac{20}{W} = \frac{400}{W} = \frac{40}{\text{per cent of wear.}}$$

Here *W* is the weight in grammes of the detritus under 0.16 centimeter (1/16 inch) in size per kilogramme of rock used.

In this test the same is thrown the length of the cylinder twice at each revolution, so that the individual stones grind against each other, as well as against the sides of the cylinders. The rocks are likewise somewhat broken by the impact, so that the abrasion test may be considered as one not only for hardness, but also for toughness.

(To be continued.)

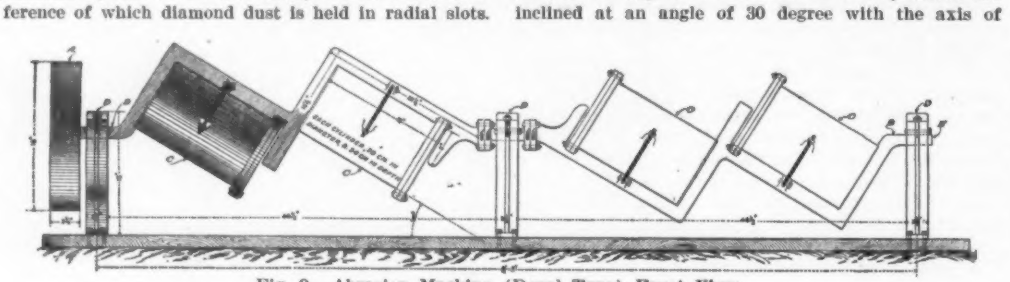

Fig. 9.—Abrasion Machine (Deval Type) Front View.

American Research Work on Rails*

By M. H. Wickhorst

SEVERAL years ago the number of rails in the United States that failed to give normal service or that broke under moving trains became alarmingly large. The worst condition was reached about 1905. The circumstances so agitated the executive officers of the railroads that the matter was made the subject of an investigation by the American Railway Association, an organization of railroads dealing with matters of railroad operation of common interest.

Reliable general statistics are not available to show numerically the exact condition as regards rail failures, but an idea may be obtained from the report of one road that, of a lot of 10,000 tons rolled and put in the track, 22 per cent were removed in the first year on account of depressions in the head. When broken apart the majority of these rails showed interior openings in the head running lengthwise of the rail. Happily that extreme state of affairs has passed.

RAILROAD CONDITIONS.

The wheel loads of the rolling equipment, locomotives, passenger cars and freight cars had been rapidly increasing for twenty years or more. H. V. Wille has shown that the average total weight on drivers increased from about 69,000 pounds in 1885 to over 180,000 pounds in 1907, and reached a maximum of 316,000 pounds in that year. The average axle load increased from 22,000 pounds in 1885 to 48,000 pounds in 1907. Since then the axle loads have still further increased.

During the same period the weight of rail (in main line track) increased from about 65 to 75 pounds per yard to 85 to 100 pounds per yard, which are also now the prevailing weights. The moments of inertia increased from about 15 to 20 to about 30 to 45. At the time the American Society of Civil Engineers adopted standard sections in 1893, 80-pound rails were just coming into use. Considered as a girder, the strength of the rail increased about at the same rate as the axle load increased, the unit stress in tension remaining about the same or even decreasing slightly. The unit stress in compression, however, increased almost as the axle load increased, as the average width of rail head increased only from about 2⅜ inches to about 2¾ inches, and the diameter of the wheels has remained about the same.

STEEL MILL CONDITIONS.

While the railroads were thus busy increasing the capacity of their motive power and cars, the steel mills were likewise endeavoring to obtain increased tonnage. These efforts took the form of eliminating unnecessary delays, installing larger converters and more powerful machinery, using larger ingots, and sometimes of allowing less time for the chemical reactions. At the height of the tonnage endeavor in the rail mills, about five years ago, there was considerable rivalry between the different mills to produce the greatest tonnage, and it reached a condition that might almost be termed madness, that had only secondary regard for the quality of the product. The purchaser had the choice of buying rails as made by the mills or going without them. Recently, however, there has been a happy change, so that quality is being given due consideration and mutual consultations are taking place. The change was due, presumably, to the chastening effect of slack orders for rails and the present state of public opinion.

INVESTIGATION BY THE RAILROADS.

In 1906 the American Railway Association took the matter in hand through its Committee on Standard Rail and Wheel Sections, which committee made a report in 1908 submitting some new designs for rail sections and also offering some tentative specifications. The matter was then referred to the American Railway Engineering and Maintenance of Way Association, now called (since April, 1911) the American Railway Engineering Association.

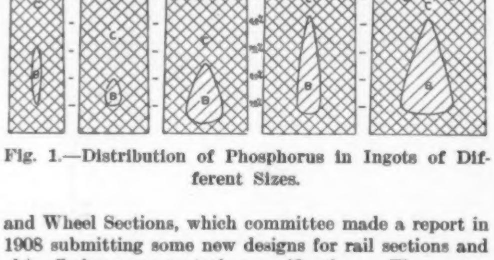

Fig. 1.—Distribution of Phosphorus in Ingots of Different Sizes.

The prevailing type of failure seems to have been the split head, generally termed "piped rail." The rails developed internal cavities, mostly in the head, running lengthwise of the rail for distances of several feet or more. It seems to have been the prevalent opinion that this and other types of failure as well as poor wear were due partly to internal structural defects and partly to finishing the head of the rail at too high a temperature. It was argued that the flanges were too thin, cooling quickly in the rolling, and that a temperature necessary to finish the flanges properly left the temperature of the head unduly high.

The remedy suggested was to make the flanges thicker, thus allowing of more uniform finishing temperature throughout the section. W. R. Webster wrote in 1901 as follows: "The cause of the trouble is now well known, it being due to the large mass of metal in the head carrying the heat so much longer than the thin metal in the flanges, thus preventing the work of rolling on the head at sufficiently low temperature to break up the coarse grain and produce the tough, good wearing rails desired." The committee of the American Railway Association later shared this same view to a large extent, as evidenced by the fact that the main feature of the rail designs they presented was the greater thickness of the flanges.

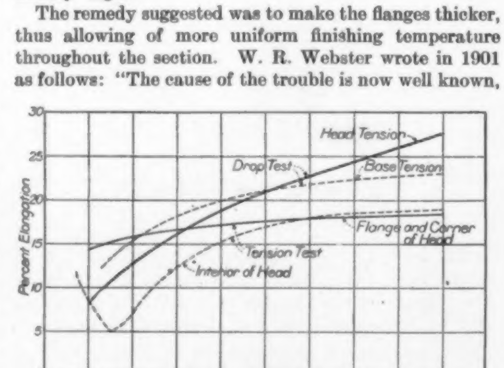

Fig. 2.—Ductility of Rails in Drop Test and Tension Test Compared.

Recent work, which will be referred to later on, indicates that from the standpoint of safety high temperature of rolling is not detrimental, and that few if any failures can be attributed to this cause. I am referring now to splithead failures in Bessemer rails, as this was the prevailing type of failure, and open-hearth steel had not yet come into extensive use. The recent work has also shown that such failures occur almost entirely in badly segregated metal from the top part of the ingot, attended perhaps with laminations and slag seams. Under pressure the top of the head of the rail spreads sideways, and as the interior of the head with such metal as referred to cannot likewise extend laterally it develops a crack, which grows until failure results. Of course, increase of pressure would hasten the development of such failures.

It has indeed been more or less definitely recognized that splitheads occurred mostly in rail from the upper part of the ingot, but the blame was placed on internal structural defects. The trouble is now well known, it being traceable to the large mass due to blowholes and pipes in that part of the ingot; the rôle of segregation was but vaguely recognized. In Europe the part played by segregation had probably been more definitely worked out years before, but the results of that work seem to have been overlooked or at any rate their importance had not been fully appreciated in America

ARRANGEMENT OF RECENT WORK.

As stated, the matter was turned over in 1908 to the American Railway Engineering Association to continue the work of investigation. This association appointed a committee, which continued the investigations started by the committee of the American Railway Association, and which also made a co-operative arrangement with the manufacturers of steel rails by which the latter furnish the material and facilities of their mills for research work, and the railroads furnish the engineer to conduct the tests under the direction of their committee and publish the results. The writer was honored by selection for the position of engineer of tests and entered upon his duties February 1st, 1910. The full reports of the work done in 1910, together with other matter collected by the committee, are published in the Proceedings of the American Railway Engineering Association, 1911, Part 2, and it is expected that the reports of the work done in 1911 will appear in the Proceedings for 1912. Herewith are indicated some of the main results obtained, but those specially interested are referred to the above Proceedings for the full reports.

SEGREGATION AS INFLUENCED BY SIZE OF INGOT.

An investigation was made of ingots of Bessemer steel of various sizes from 12×12 inches to 25×30 inches at the bottom, all about 5 feet high, weighing from 2,000 to 10,000 pounds. As part of the investigation, a chemical survey was made of these ingots to determine the dis-

*Paper presented to the Sixth Congress of the International Association for Testing Materials, New York, September, 1912, and published in *The Iron Age*

tribution of the various elements, particularly as influenced by the size of the ingot.

The distribution of phosphorus in the various ingots is shown in Fig. 1. It may be said that carbon and sulphur show a similar distribution, differing, of course, as to the amounts in the various regions. The diagrams indicate that the regions of concentration of the phosphorus, figured as a percentage of the volume of the ingot, increase as the size of the ingot increases; the analyses also indicated that the maximum concentration of phosphorus in the segregated region increases as the size of the ingot increases.

The regions of negative segregation, that is, decrease of phosphorus below the average of the steel as poured, are also of considerable interest. The top of the ingot shows considerable decrease of the phosphorus, carbon and sulphur, and this decrease extends downward along the sides a greater distance in the larger ingots. The analyses also showed that the amount of the deficiency in phosphorus increased in a general way as the size of the ingot increased. This means that the outer parts of the section of a rail made from the upper end are softer than the average of the steel from that ingot, and this has been found true of rails examined by means of tensile tests. There is also a region of milder negative segregation in the interior and lower part of the ingot.

DUCTILITY OF RAILS.

A comparison of the ductility of rails made by the ordinary Bessemer process, as measured in the drop test and in the tension test, is interesting. Fig. 2 is given to show the comparison. The distance from the top of the ingot in per cent of weight is plotted horizontally and the per cent elongation is plotted vertically. The elongation in the tension test was measured on a testpiece ¼ inch diameter with a gage length of 2 inches. The elongation in the drop test was measured by placing gage marks near the middle of the length of the piece of rail on the side in tension, 1 inch apart, for a distance of 6 inches, and the length of the space which stretched most when broken under the drop was taken as the measure of the ductility of the rail in the drop test. Two curves are given showing the ductility of the rail bar in the drop test, one with the head in tension and the other with the base in tension. Two other curves are given showing the ductility of the rail bar in the tension test, one representing the interior of the head near its junction with the web and one representing the average of the flange and the upper corner of the head, as the results from these two locations were about the same.

In the tension test the exterior metal (as represented by the flange and the corner of the head) shows good ductility along the whole rail bar, although there is a general increase as we go down the ingot, from about 14½ per cent elongation at 10 per cent from the top to about 18½ per cent elongation at 90 per cent down. The results from the interior of the head near the web, however, differ considerably from these. There is fair ductility near the top, the elongation then drops off to less than 5 per cent at about 15 per cent from the top, and it then rises again and in the lower part of the rail bar averages slightly above the results from the exterior of the section.

In the drop test with base in tension, the elongation runs from 12 per cent to 24 per cent. With the head in tension there is also a continuous increase in going down the ingot, but the differences in elongation are much greater (8 per cent to 27 per cent). In this respect there is considerable similarity between the ductility measured in the tension test of samples from the interior of the head and the ductility as measured in the drop test with the head in tension. It would seem, therefore, that this latter test may be more useful to ascertain the ductility of the interior metal than the drop test with the base in tension, as is usual in inspection work. Since the above was first written the *Railway Age Gazette* (December 8th, 1911, p. 1,176) has abstracted an article by C. Frémont in *Le Génie Civil*, in which Frémont comes to about the same conclusion, but goes a little further and recommends that some of the top of the head be first planed off and the rail then tested by the drop test with the head in tension.

INFLUENCE OF TEMPERATURE OF ROLLING.

An investigation was made to determine the influence of the temperature at which the steel is rolled on the properties of Bessemer rails. A series of five ingots from one heat of Bessemer steel was rolled into rails, all in similar manner except as to the temperature at which they were rolled. One ingot was rolled "cold" and the temperature was increased with the succeeding ingots, finally rolling the last ingot very hot. The influence of the temperature as ascertained by these tests may be summed up as follows:

The ductility and deflection in the drop test were influenced little, if any, by the rolling temperature. The number of blows that it took to break the rails in the drop test was uninfluenced by the temperature of rolling. The yield point and tensile strength in the tension tests were influenced little, if any. The elongation in the tension test decreased some as the temperature increased. The influence of temperature showed most prominently, in the tension test, in the reduction of area, which decreased as the temperature of rolling increased. The size of the grain, as shown by the microscope, increased as the temperature increased.

PLAN OF WORK.

The general plan of our research work has been to direct attention to some one item which enters as a factor in the properties of the finished rail and attempt to obtain definite information concerning its influence by the experimental method of obtaining as great a range as practicable in the one item under consideration, but leaving all other conditions as near alike as possible. It is thus hoped to aid in establishing in the course of time the metallurgical principles and laws that apply to the manufacture of steel rails for the purpose of designing specifications and rail sections that will give uniformly safe rails of good wearing qualities, and at a minimum cost.

The condition of co-operation in this work existing between the railroads and steel manufacturers is very gratifying and may be expected to work to the best interests of the public, the railroads and the steel mills.

Superheated Steam in Locomotive Service

Investigations Conducted at the University of Illinois

A GREAT deal has been written about the economy of superheated steam in locomotive service, but for the most part the subject which has claimed attention has been the net saving of coal which the system may effect. The saving of water has not been overlooked, but comparatively little attention has been paid to the cost of producing the superheated steam to be used. The question has seldom been fairly faced. Perhaps it has even been intentionally ignored in some quarters. There exists to-day only one set of data sufficiently comprehensive to form any guide in this question, and, to the great loss of the profession, the published particulars of this work only cover a portion of the necessary range. The data we refer to have resulted from work on the Purdue locomotive-testing plant of the University of Illinois. Commenced under Dr. W. F. M. Goss, the investigation has been extended by Profs. C. H. Benjamin and L. E. Endsley; but though a *résumé* of the latter work has been published, the full data are only available of that portion conducted by Dr. Goss. These have been published in the form of Reports by the Carnegie Institution of Washington. A curtailed edition of one of these has recently been issued by the University of Illinois,[1] and, while omitting much of the tabular matter, gives the discussion of the tests, and the comparison between superheated and saturated steam performance which appeared in the Carnegie Institution report above referred to.

The report is interesting, but on some points is not conclusive enough to settle for all time certain disputed facts, on which still further information would be of interest. For instance, the question of generator efficiency or the relative cost of producing superheated and saturated steam is left in a rather ambiguous state. Dr. Goss concludes from the tests that the combined superheater and boiler had an efficiency 4 per cent greater than the saturated-steam boiler. It is not explained, however, how this could be, though certain data would certainly appear to corroborate this conclusion. The total heating surface in the combined superheater and generator was 8 per cent less than in the original boiler, and the heat absorbed per square foot of superheater surface proved to be only from 34 to 53 per cent of that absorbed by the water surface. This low ratio of transmission, however, is apt to be misleading. It compares the superheater surface with the whole of the water-heating surface, which latter, of course, includes the fire-box surface, through which the transmission is very high. If the superheater surface be compared with the water-tube surface, the disparity is not nearly so great. In fact, it appears in some classes of superheater that the loss of efficiency due to this difference may be small, or possibly non-existent, though it is doubtful whether this be so in the type with which Dr. Goss' report is concerned.

In view of the moderate degree of superheat obtained in this instance, and of the fact that the heat remaining unabsorbed in the gases after passing over the superheating surface would be expected to be greater than in the case of water surface, it might reasonably be supposed that the heat lost in the case of the superheater and boiler combined would be greater than in the saturated-steam boiler. Dr. Goss, unfortunately, does not enter into any discussion of this question, but it has recently been taken up by Mr. Lawford H. Fry, M. Inst. C.E., in an article contributed by him to the *Railway Age Gazette*, on "The Utility of Flue-Gas Analyses in Locomotive Testing."[2] In this article the author concludes that the efficiency in the case of the superheater generator and saturated-steam boiler was identical, but that, incidentally, in the superheated-steam boiler more air appears to have been drawn through the grate than in the case of the saturated-steam boiler.

If we accept this, the total heat generated from the coal must have been greater, and the loss in unburnt coal less, in the former case than in the latter; and though more heat was produced, only an equal quantity was utilized owing to the reduced surface. The efficiency of absorption, i. e., the percentage of the heat utilized to that produced from the coal, was between 81 to 85 per cent in the case of the saturated-steam boiler, and 78 to 81 per cent in the case of the superheated-steam generator.

The conclusion that the loss in unburnt coal is lower in superheater engines than in saturated-steam engines seems to be substantiated by at least some experience in actual practice. With such varying conditions as occur in locomotive work, a general statement on such a matter needs to be supported by a large number of accumulated facts. There are a few known cases in which trouble has been taken to measure the smoke-box ash, but such figures as are available show this to be much less in the case of superheater than in non-superheater engines. While not conclusive, this is suggestive that the whole loss in unburnt coal may very well be less in the case of the former than with the latter.

Mr. Fry's interpretation of these tests at Purdue infers that more air was used for combustion in the case of the superheater tests than in the others. This, of course, might arise, as he appears to conclude, from a difference in smoke-box conditions. The smoke-boxes were, of course, unlike. One boiler had the usual American front end with netting and diaphragm, while the other contained netting and the superheater damper-box. It is possible that the obstruction to the lower tubes may have been less in the case of the superheater boiler than in the saturated-steam boiler, but there does not seem to be much choice between the two arrangements as regards general freedom at the front end. On another hypothesis the greater quantity of air drawn through the superheater boiler may merely have been incidental to thinner firing. It is fairly well known that thinner fires can be worked on such engines than on saturated-steam engines, and this would appear, therefore, to afford a clue, though no light is thrown on this point by Dr. Goss.

The interpretation placed thus upon these tests seems, therefore, more or less in agreement with results obtained in service. Conclusions, however, must not be too hastily arrived at. For one thing, the tests refer to a steam-generator giving steam of no very high degree of superheat, while for another it is open to question whether some of the relations are quite satisfied by the curves adopted. For instance, Mr. Fry's argument is based upon his opinion that the boiler efficiency in relation to rate of working is satisfied by identical curves for both the saturated and superheated-steam generators. Dr. Goss did not come to this conclusion, and omitting, for some unexplained reason, certain superheater tests giving low results, found the saturated curve to be, in his opinion, lower than that for the superheater boiler. A consideration of the points obtained for the saturated boiler, plotting equivalent evaporation per 1 pound of dry coal against equivalent evaporation per square foot of grate area per hour, leads to the conclusion that the expression adopted as satisfying conditions in this boiler is a fair interpretation of these tests. We are not so well satisfied with the superheater tests, however, and in this case a line of less slope seems to fit the points just as well as that adopted by Mr. Fry. If such a line be taken, it would seem that the efficiency of the superheater generator is less than the saturated-steam boiler at low rates,

[1] University of Illinois Bulletin No. 57. "Superheated Steam in Locomotive Service," by Dr. W. F. M. Goss. Published by the University, Urbana, Ill., U.S.A. Price 40 cents. London Agents: Messrs. Chapman and Hall, Limited.

[2] *Railway Age Gazette*, June 21st, 1912, page 1536.

and greater at high rates of working—a state of affairs which there seems some reason to believe approximates to facts so far as they are at present known. It may be pointed out that at low rates of working the heat absorbed by the superheater elements is low, and this would seem to tend to inefficiency at low rates. At higher rates the heat absorbed by the superheater surface is much higher relatively to that absorbed by the water-heating surface. The scrubbing action inside and outside the superheater tubes is increased and the transmission improved, making for higher efficiency for the whole generator.

The superheater boiler tests at Purdue showed in one respect results which we believe to be quite unusual. As recorded in the reports, the sparks ejected from the chimney appeared to have a greater value than those retained in the smoke-box. We are aware of no other tests in which this position is not reversed. It would seem logical to suppose that as the larger cinders passing through the tubes are less thoroughly consumed than the smaller, the smoke-box cinders would have a higher value than the smaller dust passing through the netting and up the chimney. Most of the available information supports this conclusion. It may be as well, however, to remember that with friable coals a large quantity of coal-dust passes direct from the shovel to the tubes and stack without getting near the grate.

The bulletin to which we referred above concludes with a summary comparing tests made more recently by Profs. Benjamin and Endsley with the high-degree superheater engine, with those made earlier by Dr. Goss with the moderate superheat and saturated-steam engines. The information in this connection is rather meagre, and does not therefor offer itself to criticism. It is to be hoped that some day more extensive details of the later tests may be forthcoming. There are so many interesting facts in connection with superheater locomotives awaiting elucidation that means of carrying conclusions further than is possible at present would be greatly welcome, especially if they emanate from such a plant as that at Purdue, from which so much good work has issued.—*Engineering.*

Recent Discoveries of Ancient Man*

The Neanderthal Type Probably Not the Ancestor of Modern Man

By Prof. Arthur Keith, M.D., LL.D.

"Throughout our early education we have been accustomed to such strict economy as elates to the chronology of the earth and its inhabitants in remote ages, so fettered have we been by old traditional beliefs, that even when our reason is convinced and we are persuaded we ought to make liberal grants of time to the geologist, we feel how hard it is to get the chill of poverty out of our bones."—Sir Charles Lyell, 1864.

THE steamer which sails from London every Saturday lands its passengers at Bordeaux on the following Tuesday, right on the threshold of that wonderful part of France which in recent years has given us several missing chapters in the history of ancient man, chapters which depict phases in the life of mankind long anterior to the days of the pyramids or of the oldest civilizations of the East. The country which has proved to be the record office and treasure house of prehistoric man is drained by the Dordogne, which joins the Garonne a few miles below Bordeaux (Fig. 1). A leisurely train journey of eighty miles up the valley of the Dordogne eastward brings the traveler to Le Buisson, a mere railway junction, where he finds himself within easy reach of those sites which have been made famous of

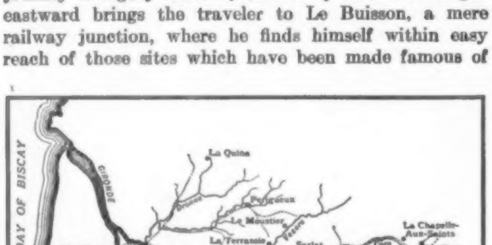

Fig. 1.—Sketch Map of the Dordogne, Showing the Sites at Which Recent Discoveries of Neanderthal Man Have Been Made.

late by the discoveries of French anthropologists and archæologists.

On alighting at Le Buisson the traveler sees the valley of the Dordogne stretching away toward the east, bounded on each side by steep and weathered bluffs of soft rock. On the floor of the valley between the bluffs lies a strip of meadow land with the river rippling in the sunlight as it meanders from side to side. It was in the caves and rock-shelters along the sides of this picturesque, peaceful and not unfruitful valley that prehistoric man made his home and where he has left his handiwork and, in some cases, his bones, to tell us the story of his time.

At Le Buisson it is better to leave the Dordogne and turn northward along the narrow and tortuous valley of its tributary, the Vézère (Fig. 1). The caves, rock-shelters and terraces along this valley have been explored and studied for more than fifty years by the French *savants.* Numerous sites of prehistoric man have been discovered, but none is more instructive than that at La Ferrassie near the village of Le Bugue, an old settlement at the foot of the cliffs on the western side of the valley, four miles above Le Buisson. Ten years ago M. Peyrony, the schoolmaster at Les Eyzies, a cliff village four miles further up the Vézère valley, began to explore the débris which had accumulated at the foot of the cliff or rock-shelter of La Ferrassie; later he was joined by Prof. Capitan, of the Collège de France, Paris. In 1909 the working face of their exploratory excavation at the foot of the cliff showed seven distinct strata lying one above the other (Fig. 4). The upper stratum, 4 feet in depth, was composed of the rubble and dust which, in the course of centuries, had been detached by the weather from the face of the cliff, forming a soil for the growth of plants. The upper stratum shows how the weather is slowly widening the valley by wasting the face of the bluffs which bound it. The second layer, nearly 3½ feet thick, was composed of altered material; it contained worked flints and remains of animals which showed that the

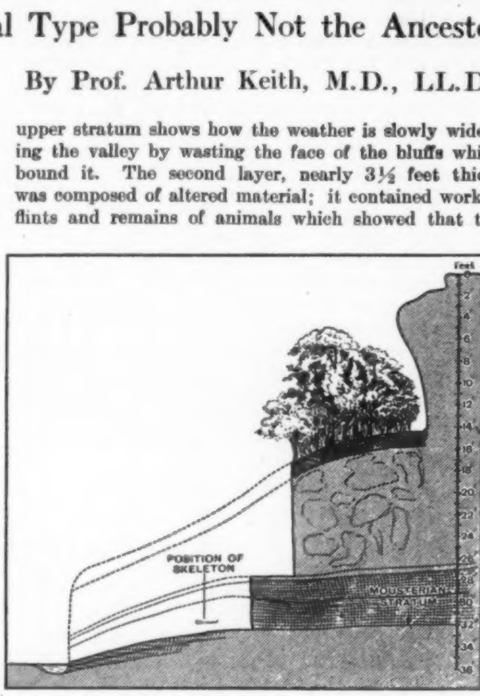

Fig. 2.—Section of the formation at La Quina, where Dr. Henri Martin discovered a skeleton of Neanderthal man. The stratum in which the skeleton lay represents a deposit in an ancient bed of the adjacent stream. The ancient bed is buried beneath débris which has fallen from the cliff. (After a drawing in *La Revue Scientifique.*) The strata removed during Dr. Martin's excavations are represented by stippled lines.

stratum was formed in that period of Palæolithic culture known as the upper or later Aurignacian.[1] The

[1] Our readers who wish to have a recent and authoritative introduction to the present state of our knowledge of the cultural ages of the Palæolithic period should obtain the British Museum Guide to *The Antiquities of the Stone Age,* revised in 1911 by Mr. Reginald A. Smith.

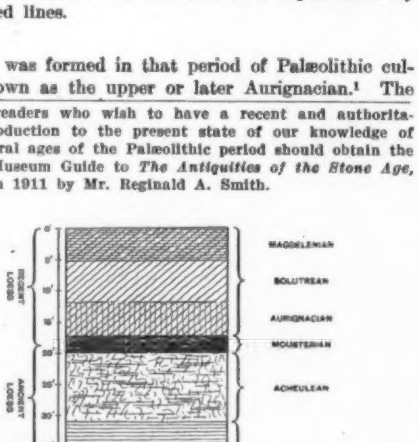

Fig. 3.—A diagrammatic section of the sand-pit at Mauer, showing the strata overlying the human mandible found there in 1907. The various deposits or strata are indicated at one side and the corresponding cultural phases of ancient man on the other. (Modified from Prof. Schoetensack's Monograph.)

third stratum, only 1½ feet thick, was recognized from its contents as middle Aurignacian. The lower or early period of the same culture was represented by the fourth stratum, less than a foot in thickness. The fifth stratum, 1½ feet thick, contained flint implements of a totally different and older civilization or culture, the Mousterian. The sixth stratum, about the same thickness as the Mousterian, but older than it in formation, was strewn with specimens of a still more ancient type of worked flints, the Acheulean. The seventh or deepest stratum contained no signs of man's work nor evidence of his residence here. Operations carried out in September, 1909, exposed in the fifth or Mousterian stratum,

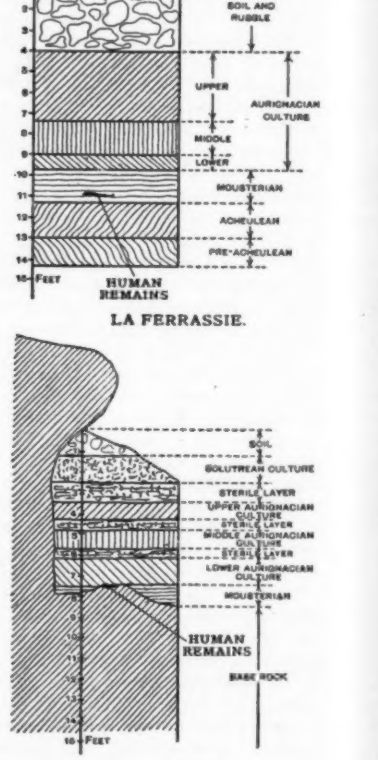

Fig. 4.—A diagram showing the various layers or strata on the floor of the ancient settlement at the rock-shelter of La Ferrassie, where the skeleton of a Neanderthal man was found; and at Combe Capelle, where that of a man of the modern type was discovered. The strata are named according to the nature of the worked flints and other signs of human industry found in them. Each stratum, therefore, represents a cultural age.

at a depth of 10 feet from the surface, a human skeleton belonging to that very distinct race or type of man known as Neanderthal. Of the kind of men who lived at the rock shelter of Ferrassie during the preceding or Acheulean and the succeeding or Aurignacian ages we know nothing; all we are certain of is that during Mousterian times the men were of that peculiar type known as Neanderthal. One would like to know the number of years represented by the 14 feet of strata at La Ferrassie; on that point we can only say that the strata represent the growth of many thousands of years and belong to that epoch of the earth's history

* Reproduced from *Bedrock.*

which precedes the present, the Pleistocene period. The Neanderthal skeleton found at La Ferrassie is the third of a series of four which have been discovered since 1908. Le Moustier, where the first of the series was discovered, is situated on the western bank of the Vézère, fifteen miles above La Ferrassie (Fig. 1). Behind the village rise the familiar reddish limestone cliffs which provided shelter for prehistoric man. The accumulated débris of the caves, recesses and terraces at Le Moustier have yielded the characteristic forms of stone culture long known as Mousterian. Here in 1907 came the Swiss archæologist, Herr O. Hauser, to try his luck in a field already made famous by his French colleagues. Early in 1908 in the floor of one of the lower caves he exposed the skeleton of a young man and brought down to this picturesque valley in the very heart of France a little army of German anthropologists, among them Prof. Klaatsch, of Breslau, to witness the final exhumation of the fragile remains of that remarkable youth to which Klaatsch gave the name of *Homo Mousteriensis Hauseri*, and made the subject of a number of long, learned and often wearisome papers. Although only about seventeen years of age the prehistoric Mousterian had all the characters of Neanderthal man well developed, the beetling brows of the anthropoid ape, massive face and jaws and clumsy, thick-set limbs. Neanderthal man was, as Prof. Schwalbe has clearly demonstrated, really a distinct species of mankind. The worked flints, purposely interred with the body, showed that this youth certainly belonged to the period of Mousterian culture.

In the month of August, 1908, while the German party was assembled at Le Moustier, a band of French archæologists, MM. les Abbés J. Braysonnie, A. Braysonnie and L. Bardon, were uncovering in the floor of a cave near the village of Chapelle-aux-Saints one of the most remarkable of the Neanderthal skeletons so far discovered. The site of this discovery lies over 100 miles to the east of Le Moustier, in the Department of Corrèze and within the watershed of the Cère, a large tributary of the Dordogne (Fig. 1). With the skeleton, that of rather an aged man, were found the flints and animal remains which characterize the period of the Mousterian industry or civilization. The human remains found at La Chapelle-aux-Saints have been examined by Prof. Boule of Paris who, at the beginning of the present year, published a full descriptive account which adds very materially to our knowledge of Neanderthal man and proves him to be very sharply marked off from all modern races of mankind.

The fourth of the recently discovered Neanderthal skeletons was found by Dr. Henri Martin at La Quina, in September, 1911. La Quina lies seventy miles to the northwest of Le Moustier, and is situated in the narrow valley of the Voultron, a small stream which, although in the Department of Charente, lies within the watershed of the Dordogne (Fig. 1). The Voultron meanders from side to side of its valley, here and there washing against the foot of the limestone bluffs on either side. For several years Dr. Martin had been exploring an old bed of the Voultron which lies buried beneath 10 feet of debris detached at different times from the adjacent cliff (Fig. 2). The stratum proved to be rich in objects belonging to the Mousterian form of industry. His efforts were finally rewarded by the discovery of a skeleton marked by all the characteristics of the Neanderthal race. In Dr. Martin's opinion the individual to whom this skeleton belonged had fallen or been thrown into the ancient Voultron and become engulfed in the ooze of its bed, finding a resting place amid the remains of contemporary animals and objects of culture belonging to the Mousterian period.

Before leaving the region of the Dordogne it is important that we should glance at another recent discovery which has a very direct bearing on the problem of the evolution of modern man. Herr O. Hauser, in 1909, the year following his successful exploration at Le Moustier, tried his fortune along the valley of the Couze, a small and southern tributary of the Dordogne which joins the parent river some twelve miles below the Vézère. The site selected for investigation was situated at the foot of an overhanging cliff or rock-shelter, high up on the terraced side of the valley near Combe Capelle. Herr Hauser found that the ground at the foot of the cliff was made up of strata trampled down by generations of prehistoric men who had used the rock-shelter as a home. The various strata and the marks of cultures they contained were almost the same as at La Ferrassie, in the Vézère valley, about twenty miles to the north of Combe Capelle. The upper stratum (Fig. 4), rather over a foot in depth, was made up of black soil and blocks of rubble detached by the weathering of the overhanging cliffs. The second layer, rather over 1½ feet in depth, was marked by the culture of the Solutréan age, a later phase of culture than any represented at La Ferrassie. Then followed three strata, separated by sterile layers, layers containing no traces of man, representing the upper, middle and lower Aurignacian cultures. The last and lowest stratum of all was less than a foot thick; it contained clear evidence of having been formed during the Mousterian age. The older Acheulean stratum, present at La Ferrassie, was absent here. At La Ferrassie the deposits began during the period of the Acheulean culture and ended in the Aurignacian; at Combe Capelle they began with the Mousterian and ended with the Solutréan. In the lowest Aurignacian stratum at Combe Capelle a human skeleton was found at a depth of seven feet from the surface. The remains of shell necklaces and other objects of ornament and industry found with the skeleton render it certain that here we have to deal with the remains of a Frenchman of the Aurignacian age. He has not a single character of the Neanderthal race, in every feature he belongs to the modern type of man, yet he lived in the age which immediately succeeded that of Neanderthal man.

These discoveries in France have completely altered our conception of the relationship in which Neanderthal man stands to the modern races of mankind. We supposed that Neanderthal man represented a stage in our evolution during the Pleistocene epoch. These recent discoveries show that he is confined to a definite and limited age of the Pleistocene; in strata older than the Mousterian we know nothing of him; in strata more recent than the Mousterian he is unknown. He appears suddenly as if by invasion; he disappears as suddenly, apparently by extinction. We cannot suppose that at the sharp border line which separates the Mousterian from the Aurignacian age Neanderthal man was miraculously transformed into a type of modern man. We must infer that in the latter part of the Pleistocene period there were at least two kinds of men existing in Europe, the Neanderthal and the modern. The distribution of those two types of men in the world and the existence of other human species at that period of time we can know only when the Pleistocene strata throughout the earth have been systematically investigated.

Prof. Klaatsch has published very full descriptive accounts of the man found at Combe Capelle; there is not a single feature that marks him off from modern human races. So impressed was Prof. Klaatsch by the essential differences between the men of the Mousterian age and those of the succeeding one that he propounded the theory that they were descended from different stocks, the Neanderthal springing from the same stock as the gorilla, while modern types shared their lineage with the orang. The vast majority of anatomists who are investigating the problems of man's origin look upon Klaatsch's explanation of the differences between the Neanderthal and modern human races as highly fantastic; there can be no doubt that they do not bear even a superficial examination. Great as are the differences between these two kinds of beings, both equally deserve the title of "human." The points of resemblance between them are so close and so numerous that we can explain their close structural relationship only by supposing that Neanderthal and modern man have arisen from a common stock at a very distant date, long anterior to the latter part of the Pleistocene.

It is easy to bring forward a number of instances which illustrate how distinctive are the structural features of Neanderthal man. In the course of his excavations at La Quina the year before he exposed a complete skeleton, Dr. Henri Martin found two ankle bones (astragali) which he forwarded to Prof. Boule. That authority immediately recognized them as distinctive of Neanderthal man. It is impossible for an anatomist to distinguish with any degree of certainty the astragalus of one modern human race from that of another. When, in 1910, the Société Jersiaise explored the cave in the cliffs of St. Brelade's Bay, on the south coast of Jersey, a number of human teeth were found which were submitted by Mr. R. R. Marett to Mr. Knowles and the writer for an opinion. We were able to recognize at once that they were the teeth of Neanderthal man although at the time we were not aware of the fact that the worked flints found with them belonged to the Mousterian culture. The teeth of Neanderthal man are highly specialized; they are less anthropoid in character than those of many modern races of mankind. A fragment of the skull, a part of the lower jaw, a bone of the arm or of the leg, is enough to provide a basis for a sure diagnosis. As our knowledge increases of this peculiar form of being we see that Prof. Schwalbe of Strassburg was absolutely right when, in 1904, he separated Neanderthal man under the designation of *Homo primigenus* from modern man, *Homo sapiens*. And yet the name does Neanderthal man an injustice; in spite of the fact that he retains the beetling eyebrow ridges, the squat massive skull hafted deeply on the neck, and certain other anthropoid characters, there is no need to withhold the title of *sapiens* from him, for in point of size of brain he outstripped his contemporary, the modern type of man. Of the two Pleistocene representatives of mankind Neanderthal man is the more primitive, the more anthropoid; and we must therefore suppose that he more nearly represents a remote stage in the evolution of man. While the recent researches in France make it certain that modern man was not evolved from Neanderthal man in the latter part of the Pleistocene epoch, they do not help us to answer the questions as to when, where and how modern man came into existence. For that information we must search elsewhere.

While we are confident that one cultural age succeeded another in ancient France in a definite sequence, a sequence which research during recent years has shown to hold true for the greater part of Europe, we have to seek in places other than caves and rock-shelters for the facts which will give us a clue to the length of these cultural ages of prehistoric man and their approximate date in the past. More than twenty-five years ago it occurred to Prof. Boule that it might be possible to correlate these cultural phases with the glacial or cold cycles which recurred in the Pleistocene epoch. He found worked flints under the deposits of Alpine glaciers belonging to the last cycle, but none under the deposits of the one which had preceded it. He, therefore, concluded that the oldest cultural age did not extend beyond the milder period which intervened between the last and the penultimate cycles. About the same time as Prof. Boule began his investigations in France, Dr. Penck, now Professor of Geography in the University of Berlin, devoted himself to a study of the moraines and deposits of the Alpine glaciers during the Pleistocene epoch. He found evidence of four successive cycles, three of them occurring in the Pleistocene epoch, the first or earliest in the Pliocene. In his opinion remains of human culture extend a cycle further back than Prof. Boule thought. I have no intention here of entering into the details of the sharp dispute which now separates the French and German schools concerning the exact relationship of cultural ages and glacial cycles. I prefer to turn to another line of evidence which bears on the length and remoteness of the various cultural phases of ancient man, namely, that afforded by a study of deposits and changes in river valleys.

The river deposit which best serves our present purpose is that laid down by the celebrated tributary of the Rhine, the Neckar, near the village of Mauer, between Heidelberg and Mannheim. By good fortune this deposit in the ancient bed of the Neckar proved valuable to the builder and was worked so extensively that in the year 1907 a working face, fully eighty feet in depth, exposed to the light of day strata which had been laid down many thousands of years before. The upper stratum is 18½ feet deep (Fig. 3), and represents recent loess, a deposit which, thanks to the researches of German and Austrian archæologists, is now known to have been formed during the Magdalenian, the last of the Pleistocene cultural ages, and the two preceding ages, Solutréan and Aurignacian, already seen in the cave and shelter deposits of France. Beneath the recent loess lies a deposit of ancient loess, 17 feet in depth. Discoveries along the valleys of the Rhine and Danube show that the junction between the recent and the ancient loess represents the age of Mousterian culture, the age with which Neanderthal man was associated. In the opinion of German geologists this junctional zone in the loess corresponds to the last of the glacial cycles. We have no means of estimating the rate at which the loess was deposited, but it is clear that a deposit 18½ feet in depth implies a long period. Deposits which were formed at the same time as the ancient loess contain implements of the Acheulean age, the oldest seen in the cave and shelter deposits of the Dordogne.

Beneath the ancient loess lie many alternate strata of sand and gravel amounting collectively to a depth of over 46 feet. They contain the remains of animals which characterize the deposits laid down at an early part of the Pleistocene epoch. In almost the deepest stratum of the pit there was found a human mandible, massive and ape-like, the famous Mauer or Heidelberg jaw which Prof. Schoetensack of the University of Heidelberg has made known to the world of scientific men. The sand-pit at Mauer gives us a concrete representation of work done during the Pleistocene epoch; the time occupied in the formation of the 60 feet of strata which separates the horizon of the Heidelberg man from that of Neanderthal man we have as yet no means of estimating; but if we accept the very modest estimate of 400,000 years as representing the length of the Pleistocene epoch, then we must allow at least 200,000, probably much more, for the interval between these two stages in the evolution of Neanderthal man.

I was surprised to observe a recent statement by Prof. Boule to the effect that one could not tell with any degree of certainty the nature of the Heidelberg man from a study of so slight a part of him as the mandible. On the contrary, it is my opinion that there is no bone of an animal's body, if that type of animal is already known, which can give us so much precise knowledge as the lower jaw and teeth. The type of

jaw represented by the Heidelberg specimen is not new to us; it is in every feature merely a primitive form of the well-known Neanderthal type. Prof. Boule found that a cast of the Heidelberg jaw made a natural fit when applied to the skull found at La Chapelle-aux-Saints. We must, therefore, suppose that the other parts of the Heidelberg man were perhaps more primitive yet modelled on the same plan as in Neanderthal man. One has merely to study the complete dentition preserved in the mandible from the Mauer pit to see that we are dealing with a form of man in some respects very highly specialized. In form and structure the dentition is less simian than that of a modern Australian native or of the extinct natives of Tasmania. In the early Pleistocene deposits of the Neckar we have found, then, not the precursor of modern man, but of the Neanderthal race which flourished in Europe during the age of the Mousterian culture. The forerunner of modern man during early Pleistocene times has still to be found.

We now return to England to study the bearing of recent discoveries of ancient man made in the lower valley of the Thames and in East Anglia, on our conception of the origin of modern man. On the sides of the valley of the Thames remnants of four terraces, representing ancient beds of the river, rise one above the other. Seven years ago Mr. A. C. Hinton and Mr. A. S. Kennard applied to these terraces the system of dating introduced by M. Georges de Mortillet nearly twenty years ago in France, a system which, as we have seen, is now in general use on the Continent. Messrs. Hinton and Kennard regard the lowest, fourth, or 20-foot terrace as contemporary in formation with the last three cultural periods of the Pleistocene, the Magdalenian, Solutréan and Aurignacian, and therefore laid down at the same time as the deposit of recent loess of the sand-pit at Mauer. The next, the third or 50-foot terrace, they correlate with the Mousterian age, the period of Neanderthal man. The second or 100-foot terrace and the first highest, or 130-foot terrace, with the two older cultural ages, the Acheulean and Chellean. It is probable that Messrs. Hinton and Kennard would be now prepared to reconsider the dating of these terraces in the light of M. Commont's recent discoveries in the lower valley of the Somme. The valleys of the Somme and Thames are less than 150 miles apart; there is every reason for supposing that the changes which have affected the one during the Pleistocene epoch have also left their mark on the other. It is very apparent that the terraces of the one correspond to the terraces of the other; in the lower valley of the Somme the lowest or fourth terrace is submerged beneath the present level of the river; in the Thames valley it is not. In both valleys there are deep or buried channels. The third or 50-foot terrace is clearly marked in the valley of the Somme, and, what is of more importance for our present purpose, the second or 100-foot terrace is also apparent in the French valley. M. Commont found in the 100-foot or second terrace of the Somme valley the characteristic worked flints of the Chellean age and also of an older age which he names pre-Chellean. Messrs. Hinton and Kennard also ascribe the 100-foot terrace of the Thames to the same cultural period. That is important for our present purpose, because at a depth of over 7 feet in the upper terrace of the Thames near Galley Hill, in Kent, a human skeleton was found in 1888. The same stratum has yielded many of those wonderful works of very ancient art, the Chellean flint axes. The documents relating to the discovery at Galley Hill place any doubt as to the date and authenticity of this skeleton absolutely out of court. The state of preservation of the bones is that which characterizes the animal remains removed from this ancient terrace formation. Were we to use the scale of time as represented by the section exposed at the Mauer sand-pit, we should place the Galley Hill man beneath the deep deposit of ancient loess and perhaps some distance down in the strata of the sand gravels and loams which lie above the Heidelberg jaw. In point of time the Galley Hill man is intermediate to the Heidelberg man and the Neanderthal men of the Mousterian period. No trace of Neanderthal man has been found during the Chellean age; we know nothing of the links between the Heidelberg man and his descendants which appear in France in the Mousterian age.

Why is it, then, that our leading authorities, such as Prof. Boyd Dawkins and Prof. Sollas, view the Galley Hill remains with a profound scepticism? When the skull and skeleton were shown in Paris some three years ago by its fortunate owner, Mr. Frank Corner, Prof. Boule characterized it as *bric-a-brac*. If it had been the remains of Neanderthal man that Mr. Robert Elliott had found in the 100-foot terrace at Galley Hill in 1888, they would have been received with a ready acquiescence by the most orthodox of our geologists; but because they proved to be, as Mr. Newton showed they were, merely a variant of the modern type of man they were rejected with scorn. The explanation is to be found in the simple, almost childlike, conception which our senior authorities have formed of the manner in which evolution works in the production of human races. In their mind's eye they see man's ancestors in a single file receding into time, modern man gradually changing to Neanderthal as they go backward; then Neanderthal to Pithecanthropus, the fossil man of Java, and he in turn to an Anthropoid form. The problem is infinitely more complex than they suppose. When we appeal to the evidence of man's nearest relatives, the anthropoid apes, we see that there is not one kind but three living, and at least two extinct kinds, and probably a dozen more of which we have yet no knowledge. It was apparently the same at an early stage in the evolution of the human stock; there were probably numerous species and genera of humanity in very ancient times; we know of at least three distinct forms of Pleistocene man, the Pithecanthropoid, Neanderthaloid and Modern. Instead, then, of rejecting the Galley Hill man, the one known representative of the modern type of man remote during the Chellean age, because he does not fit in with our ill-founded preconceptions, we should as scientific men fit our conceptions to meet the known facts.

The importance of the discovery of human remains in the 100-foot terrace of the Thames will be apparent when we consider the antiquity of that classical age of flint culture, the Chellean. The boulder clay which was apparently deposited during the third glacial cycle in Prof. Penck's notation, was shown by Mr. T. V. Holmes to lie under, and to be therefore older than the 100-foot terrace which represents the earlier part of the Chellean age. How remote that age is, and the extreme length of its duration, become apparent if we accept the opinion of M. Rutot and also of M. Commont that the valley below the 100-foot terrace was excavated by the river since and during the Chellean age. In the Somme valley man's implements of the succeeding or Acheulean age are buried in the brick earth, sands and gravels deposited after the river had carved out its valley; more accurate observations will probably show that this also holds true in the lower valley of the Thames. The original calculation I formed of the antiquity of the Galley Hill man is, therefore, below rather than above the mark. If we allow the very moderate figure of 400,000 years to represent the whole of the Pleistocene epoch, then the position of the Galley Hill man is at least mid-Pleistocene.

We know a little of the men who lived in England during the Acheulean age, which, it will be remembered, precedes the Mousterian age, when Neanderthal man appeared in ancient France, and follows on the Chellean age. In 1888 Mr. Henry Trigg reported the discovery of part of a human skull in undisturbed brick earth at a depth of 7½ feet near Bury St. Edmunds. In the same deposit were found flints belonging to the age of Acheulean culture. I had an opportunity recently of making a thorough examination of this cranial fragment and came to the conclusion that it belonged to a human individual, not of the Neanderthal, but of the modern type. I know that my friend Dr. Duckworth is of opinion that the fragment is insufficient to afford a basis for a certain diagnosis, an opinion with which I by no means agree. The evidence found in England points clearly to the fact that her inhabitants during the pre-Mousterian periods were men of the modern type, not Neanderthaloid.

Why is it, then, that Neanderthal man has not yet been found in England? Traces of him ought to be found; he reached Jersey and lived there in the Mousterian age; the flints of his time and culture are found in England. If his remains are ever discovered in the Thames valley it will be in the more recent deposits, which occur in and over the lower terraces. It is true that his remains are said to have been found lately in a peat deposit in East Anglia. In a recent number of *Nature* (April 4th, 1912) Prof. McKenny Hughes described and figured a human skeleton which he regarded as that of a Neanderthal man. The figures and description clearly demonstrate that the learned Professor of Geology at Cambridge has applied this designation to a typical example of the round-headed men of the Bronze period, who are as unlike Neanderthal man as it is possible for modern men to be.

Of the discoveries of ancient man made in England during recent years none more deserves the serious attention of anthropologists than that which we owe to Mr. Reid Moir. For a number of years he has made a close study of the various forms of shaped flints which are found in the neighborhood of Ipswich, in the Tertiary formations of East Anglia. In the autumn of 1911 he and others associated with him found the remains of a human skeleton under a stratum of weathered chalky boulder clay and partly embedded in the subjacent mid-glacial sands. As to the kind of man there can be no doubt; he belongs, in all his features, to the modern type. Mr. Reid Moir and several well-known geologists whose advice he asked, regard the stratum of boulder clay which lay over the skeleton as undisturbed and representing a direct extension of the neighboring unweathered sheet of that glacial deposit. If that is so, then the Ipswich discovery carries the history of the modern type another glacial cycle further back; the Galley Hill man followed the glacial cycle that deposited the chalky boulder clay; the Ipswich man preceded it. The date of the Ipswich skeleton depends on the age of the overlying stratum; if it is re-deposited chalky boulder clay, as is maintained by Mr. Hazzledine Warren, then the age of the Ipswich man must be assigned to a later date in the Pleistocene. Further discoveries will show, I think, that Mr. Reid Moir is right.

I have now finished a cursory survey of our knowledge of the forms of Pleistocene man in Europe, and of its bearing on our conception of man's evolution. The recent discoveries in the region of the Dordogne have shown that Neanderthal man is confined to a restricted and comparatively late date of the Pleistocene epoch. He appears for a period and is then replaced by modern man. His transformation into modern man is refuted by both anatomical and archæological evidence. We have, therefore, still to seek for the primitive and ancestral forms of modern man. The discoveries in England show that we must go a long way further back in the geological record than is usually believed to find our ancestral form. At least in the middle of the Pleistocene period, long before the period of Neanderthal man of the Mousterian age in France, modern man had appeared in England. It is, therefore, in the Pliocene formations we are most likely to meet with the early forms of modern man. There are no deposits in England so likely to give us a clue to the ancestral forms of modern man and the date of his evolution as the Pliocene and Pleistocene strata of East Anglia. Progress can never be made until geologists and anthropologists realize that human remains must not be rejected purely on the grounds that they are similar to those of modern man. Above all, we must educate the workmen and managers engaged in every work which necessitates the exploration or disturbance of recent geological deposits. Without doubt, many valuable documents bearing on the origin of man have been irretrievably lost because of the ignorance of those who saw them and knew them not.

Asphaltum Mining in California

By E. A. Ward

(*See our frontispiece.*)

An interesting asphaltum deposit has recently been located in the southeasternmost corner of Santa Barbara County, California, which is claimed to be unique in quality, and extensive enough to pave a road sixteen feet wide and four inches deep twice around the globe.

It is estimated that it contains anywhere from thirty-five to forty-five millions tons of the bituminous sand which runs from eighteen to twenty per cent pure asphalt. Coarse and fine sand are mixed in the deposit in nearly the proportions required for roadmaking; a condition not found in any other mines in California. Only about eight per cent of rock and sand need to be added to make it ready for use. Hot shovels are used for mining it and the daily output is from fifty to one hundred tons. A mile of road sixteen feet wide requires about seven hundred tons of the material.

Wherein Truck is Akin to Trolley

It is an indication of the progress that has been made in the construction of commercial motor vehicles that owners now are inclined to place them in charge of former drivers of horses rather than qualified chauffeurs. Were the motor truck a machine of many moods and whims, so to speak, requiring the constant attention of a highly skilled mechanic, the horse driver would have no place behind the wheel; and it is only of comparatively recent times that it has been practicable to dispense with the high-priced specialist.

In this respect the motor truck is getting into the same class with the trolley car, which is intended to be driven by the motorman, but given what extra care it needs by specialists in the shops. Only in this way can the motor vehicle be made to operate with maximum economy, for it is obviously extravagant to pay a skilled mechanic to do drivers' work.

Apart from his inability to cope with mechanical troubles, the better sort of horse driver is a more suitable man for motor truck work than a regular chauffeur, not only because he is well satisfied with smaller pay, but because he is thoroughly familiar with trucking conditions and, moreover, knows many details of the handling of the material he hauls, all of which usually cannot be said of the "graduate" chauffeur. So it comes that the truck builder is solving more problems than the purely mechanical one of the truck itself, by making possible the economic division of labor.—*The Motor World.*

An Electrically Heated Microscope Slide*

A Useful Device in the Study of Liquid Crystals and Similar Objects

By F. G. Cottrell, Ph.D.

The following is a description of an apparatus devised some years ago by the author more especially for the study of liquid crystals, but which will be found convenient wherever a particularly rapid and accurate adjustment of temperature under the microscope is desired.

The essential feature of the method lies in depositing a uniform film of platinum over the glass slide, which is to carry the object, so thin as not to seriously reduce its transparency but still forming a continuous conductor for the electric current. By connecting this film in series with a suitable rheostat to a convenient source of current, such as an ordinary 110 or 220 volt lighting circuit, any temperature from that of the room to almost the melting point of the glass may be rapidly established.

To minimize the danger of cracking under the heat, especially for high temperatures, the glass slips to be coated should be made quite small and of thin glass. It has proved most convenient to make these from the thin quality (about 0.6 to 0.8 millimeters) of 1×3-inch microscope slides by cutting the latter crosswise in ½-inch widths and rubbing down these cut edges on fine emery cloth or the finest carborundum powder to eliminate any incipient crack or strain left on the edge from the cutting.

Both ends of these little ½×1-inch slides are then painted for say ¼ inch with gold paint such as is used for decorating porcelain. If this is not at hand, a good substitute is a collodion solution to which a small amount of either gold or platinium chloride has been added. In this case, the ends of the slide may be dipped in the collodion to the desired depths and the adhering film allowed to dry in the air. The slide is in either case next placed over a Bunsen burner and the heat gradually raised until the organic matter is completely burned out and a brilliant metallic surface left, which may be thickened, if necessary, by repeated paintings and burnings. If thus thoroughly fired, this is tightly adherent and will stand considerable handling. These gilded or platinized ends of the slides serve as terminals for the still thinner film subsequently to be spread between them which serves as the electrical resistance for heating.

Unfortunately this very simple method of gilding or platinizing conductive coatings on glass, while entirely adequate for these terminal strips, fails to produce sufficiently uniform thin coatings to be used for the resister, so it is necessary to resort for this to the discharge (Zerstaubung) from a platinum cathode in high vacuum, a method familiar for many years to physicists.

A convenient and easily assembled apparatus for carrying this out consists of a stout test tube, *A* (Fig. 1) fitted with rubber stopper through which pass tube *B* for connection to the vacuum pump, an aluminium wire, *C*, for an anode and a glass tube, *D*, through the inner end of which is sealed a platinum wire, *E*, to the free end of which is welded the platinum plate *F*, to serve as a cathode. This platinum wire and plate should be stiff enough to retain their position without bending if the apparatus is shaken. Electrical connection to the cathode is easily made by pouring a few drops of mercury into the glass tube and shaking it down into the end of the tube as at *G*. The negative wire from the induction coil may then be thrust down the tube into this mercury. A mica plate, *H*, may also be slipped over the cathode tube nearly up to its end to screen the inlet end of the outer tube from deposit and thus facilitate the examination of the glass slip *I* as platinizing proceeds.

This strip with its ends gilded or platinized as previously described, is slipped into tube *A* and the stopper

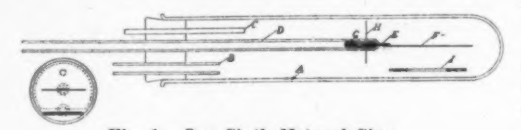

Fig. 1.—One Sixth Natural Size.

inserted and all joints thoroughly painted with molten wax, made preferably by dissolving 10 to 20 per cent of pure gutta percha in molten beeswax. The vessel is then exhausted with a mercurial air pump or other means capable of producing a vacuum of, say, 0.01 millimeter of mercury. The attainment of the required vacuum is sufficiently indicated by the appearance of the well-known green flourescence of the glass when the current from the induction coil is applied. This coil should be capable of giving at least a 1-inch spark in air.

Within less than a minute after the current has been applied, a very perceptible darkening of the walls of the test tube and the surface of the glass slip should become apparent. If the apparatus is connected to the pump by a thick-walled rubber tube, it is an easy matter to

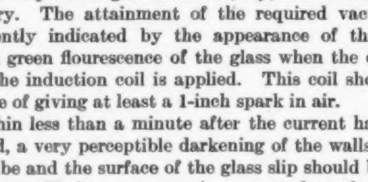

Fig. 2.—One Fifth Natural Size.

shake the glass slip back and forth past the mica screen and thus examine it through the clear walls of the left-hand end of the tube. As soon as a slight but uniform darkening of the glass beween the gilded tips is perceptible, the slip is finished and may be removed and another treated. After preparing and testing a few slides, it is easy to judge by the eye the best thickness of deposit. By sufficiently extending the time or strength of the discharge in the vacuum tube, brilliant and entirely opaque mirrors may be obtained. In fact this method may be employed to produce the heavy deposits on the ends of the slides in place of the gilding process above described. In this case the central portion of the slide is to be protected from deposit by wrapping with tin foil.

A convenient form of holder for these slips is shown in Fig. 2. On an ordinary 1×3-inch microscope slide are cemented (preferably after roughening the glass surface with emery or carborundum) the two small binding posts *B*, with large flat bases, carrying light metal springs, *C*. The gilded ends of the small glass slips are wound round with several thicknesses of tin foil and then slipped under these springs as shown in the figure. The whole slide may now be handled in the usual way, only taking care not to short-circuit the heater through the spring clips on the microscope stage if these are used.

A convenient form of rheostat for use with this apparatus consists of a glass cylinder about 1 inch in diameter by 4 inches high on a substantial foot. Through a cork stopper pass two glass-stemmed platinum electrodes similar to that described as cathode in the platinizing tube except that the platinum sheet may be much smaller or even entirely omitted. One of these should reach to the bottom of the cylinder, the other sliding easily through the cork in order to allow adjusting the distance between their tips.

The cylinder is filled with distilled water to which a drop of dilute sulphuric acid is added. For temperatures on the slide only slightly above that of the room, even higher dilution may be needed.

With non-conductors or very poor conductors as in the case of most organic compounds, the material may be examined to best advantage by placing it directly upon the platinized surface of the glass, in which case the temperature response to adjustments of the rheostat is practically instantaneous and can be controlled with the greatest delicacy while observing. With electrolytes this is not usually practical, but in this case a slip of thin cover glass may be first laid upon the heating surface. The temperature response then though still rapid is markedly slower than in the other case.

The apparatus is particularly useful in studying melting and recrystallization phenomena, as any individual crystal may be watched and its melting or crystallization instantly stopped and held constant or reversed at will.

No attempt has been made in the use of the apparatus thus far to measure the temperature, but it would seem this might be done by measuring the current flowing through the platinum with a galvanometer while measuring drop in potential across the platinum film by the Poggendorf compensation method and from these data determining the resistance of the film itself which, if pure platinum is used, should be directly proportional to the absolute temperature. While there might be some minor corrections to apply, these could be experimentally determined by observations on substances of known melting point.

* Reproduced from the *Journal of the American Chemical Society.*

The Reclaiming of Waste Rubber*

In this country, as well as abroad, factories for the reclaiming of rubber are increasing in number, in part because of the greater demand for reclaimed rubber, in part because new processes are being invented. The growing requirements of these factories in the way of waste rubber must in time render the trade in this more important, and encourage dealers in improving their organization for the searching out and collection of such material. And as it is to be expected that improvements in reclaiming processes must come, and will lead to improvements in quality of the rubber obtained, one is prepared to believe that the trade will receive gradually increasing impetus, for a bettering of quality must result in a greater demand.

One new method after another for the reclaiming of rubber has been patented, but as yet the ideal has not been attained, that of a rubber that may be used in place of virgin rubber, the whole of the sulphur of vulcanization having been removed. The typical reclaimed rubber, while it may have all or almost all of the sulphur removed that is not chemically combined with the rubber, still contains the combined sulphur. Its uses are therefore limited. But it is a difficult problem to find out how this combined sulphur may be withdrawn without injuring too greatly the quality of the rubber. Bary, who enters into the question in the pages of the *Revue du Chemie Generale*, draws attention to the view held that during vulcanization the essential constituent of the rubber becomes partly broken down, so that reclaiming processes start with a handicap against them. In reclaiming there is a race between the desulphuration of the rubber and its chemical disintegration, and the hope is to have the former complete before the latter has got a proper start. This hope has so far not been realized, and it is to give an impulse to the solution of the problem that Bary has written his review of the subject.

He has in view the complete removal of the sulphur from vulcanized rubber when in solution. In many of the patented reclaiming processes solvents alone are used, such as turpentine, naphtha, benzine, carbon disulphide and chloroform. By heating a solution of vulcanized rubber, then precipitating the rubber, say, with alcohol, redissolving it, heating this solution, then precipitating the rubber, and so on, the amount of sulphur combined with the rubber is gradually reduced. But for complete or anything like complete removal from combination with the rubber there must be used in addition some chemical substances that will absorb the sulphur as it is liberated by the heating.

Of the substances that have been proposed for this purpose, Bary has drawn up a list, dividing them into three groups. In the first he places soda, lime, barytes, alkaline carbonates and sulphides and soaps. But alkaline substances have an injurious effect upon rubber, and the process of desulphuration must be stopped before it is complete, because the rubber, when extracted, is found to be tacky and weak. In the second group he places aniline and its relatives, which not only absorb the sulphur, but also are themselves solvents of rubber. Two objections to their use are that a coloring matter forms, the reclaimed rubber being black, and that they are expensive. In the third group are the metals, their oxides, and their salts. The insolubility of these substances, or the sulphides formed, allows of their easy separation from the solution by decantation or centrifugal force. But as absorption of sulphur takes place only over the surfaces of their particles, these must be very finely divided. The substances thought the best are the peroxides of lead, manganese, iron, etc. It will be remembered that Hinrichsen and Kindscher are experimenting with metallic copper, a little metallic zinc being added.

The stages in this method of reclaiming are as follows. (1) The grinding of the waste rubber; (2) its solution, xylol apparently being the solvent recommended; (3) the heating for liberation of the sulphur; (4) the separation from the solution of the mineral and other insoluble matters; (5) the separation of the rubber by precipitation with alcohol, or more economical, filtering through an animal or other specially-adapted membrane that will allow sulphur, resins, solvent, etc., to pass and will retain the rubber.

Though the present price of rubber allows a fairly wide margin for the cost of producing reclaimed rubber, it is

* Reproduced from *The Waste Trade World.*

necessary none the less to make careful estimates. Bary puts the cost of solvent (xylol) that is lost during the process, if the rubber is separated by filtration, at about one penny per pound of reclaimed rubber. And, as far as the total cost of production is concerned, he goes no further than to say that it must exceed 2.2 pence per pound. Precipitation of the rubber by use of alcohol and the employment of other solvents than xylol may be expected to increase the total cost. A consideration of the above account of the stages through which the rubber must pass, and it may be said that it does not give anything like a complete picture of the treatment necessary, would show that Bary, when he puts the figure that must be exceeded as low as 2.2 pence per pound, has taken a modest view of the probable total cost.

He has experimented only under laboratory conditions with the metallic peroxides, but he expresses his confidence in the future of reclaiming with such substances. The demand for reclaimed rubber, in its present form, has already led to the development of a large trade in waste rubber, and no doubt dealers will wait with interest for news that successful production of an improved product is possible on an industrial scale, there being no doubt that an expanse in the trade will follow.

Securing the Ends of Elevator Cables*

THOSE who have carefully observed the behavior of elevator cables while in operation will have noted that they tend to revolve, or twist, as they run back and forth over the sheaves, the twist tending now in one direction and now in the other, as the cables run back and forth. The effect of this twisting action is to subject the cable to a varying torsional stress, which is felt most severely at the ends of the cable, if these are held solidly, so that they cannot yield. The cable is naturally affected most severely when it is strained by a twist that tends to wind its strands up more tightly, because a strain in the opposite direction can relieve itself to a considerable extent by untwisting the strands slightly.

When the end of the cable is secured by being fastened into a socket by means of melted lead or zinc or babbitt metal, the torsional strain upon it is most severe just inside of the end of the socket, where the part that is free to turn joins on to the part that is fast. This is in accordance with an accepted general principle in applied mechanics, which teaches that when any flexible or yielding structure or device is held rigidly at some one point, it suffers deterioration most rapidly at that point, from the concentration of the stresses there. Ball-bearing swivel joints may be had, to place in the cable near to the end that is held rigidly, for relieving the torsional strain by allowing the cables to turn with a considerable degree of freedom. These help to eliminate the trouble, but while they accomplish a good deal, and are far better than the unrelieved cable that is held solidly by a leaded socket, yet they are not altogether effective, because a certain amount of twisting force is required to turn a swivel when it is under a load, even though it runs on ball bearings; and the amount of stress thus called for is thrown upon the weak spot in the cable, as before. The swivel joint reduces the torsional stress, but does not entirely remove it.

Any vibration that there may be in the cable produces additional effects that will be localized at the same weak section, and will add to the likelihood of failure there. We must also remember that the end of the cable becomes heated by the act of pouring the melted metal filling around it, and the effect of this heating is probably most severe at about the end of the socket, where the hot and cold parts of the cable meet.

From these considerations, taken together, it will be plain that the section of the cable that lies just inside of the socket is a point of danger to which special attention should be given by inspectors and by all other persons who are concerned with the maintenance of elevators in good working condition. Inspectors are often criticized, even by cable manufacturers who ought to know better, for condemning cables that have been used for a considerable time, and which may appear to the uninitiated to still have a large margin of safety. We have known of many cases in which cables that are more or less frayed and broken have been removed at the suggestion of our inspectors, and have been tested, subsequently, and found to possess an unexpected amount of strength. To criticisms that may be based upon results of this kind we would say (1) that the fact that a 10-foot piece cut from the middle of a cable has a considerable strength does not prove anything at all with respect to the strength of the cable at the end, where it is secured to its socket; (2) that it is one thing to put a section of cable in a testing machine and see what it will stand, and another thing to see the cable in service on the elevator, and stake thousands of dollars that it will not give way and cause many deaths and injuries; and (3) that while no comment is made when the man at the testing machine finds that a cable that looked weak really is weak, yet if an inspector should pass such a cable for continued service, and it should afterward give way with serious results, he would be properly subject to severe criticism.

The injurious effects of twist in elevator cables may be avoided in large measure by securing the ends properly with clips, similar to those known as Crosby clips. There are numerous cheap and inferior forms of clips on the market, and care should therefore be taken to procure the best that can be had. For elevator service in particular, they should be drop-forged from a good grade of steel or iron, instead of being made of cast-iron or malleable iron. Eyes of an equally good quality should be used in the turn of the cable, and these should be of generous size so as to avoid bending the cable around too short a radius. A construction of this kind avoids the solid and unyielding resistance that is opposed to the twisting and vibratory motions of the cable by the ordinary lead or zinc sockets. The twist distributes itself through the fastening, and does not strain the cable severely at any point.

When clips are used to fasten the end of a cable, they should be sufficient in number as well as satisfactory in quality. Not less than three should be used upon each cable-end, and they should not be screwed up tightly enough to damage the cable. In fact, it is well not to attempt to screw them up to their final adjustment at the outset, a better method being to turn them up moderately at first, then up more strongly after a short period of use.

Some authorities object to the clips because they reduce the ultimate carrying capacity of the cables by about 10 per cent. We do not consider this objection to be sound, however. An elevator suspension should have a factor of safety of about ten, and a loss of ten per cent of the strength of the cable from the adoption of clips would therefore reduce the factor of safety from 10 to 9. We hold that such a reduction is of small consequence when compared with the advantage of having the whole cable exposed from end to end, so that it can be examined at every point.

It may be possible to pull the cable out, when three clips are used, if a sufficient amount of power can be exerted, while the car is held fixed; but this is not what happens in practice. Moreover, we have endeavored to make it clear, above, that the superior strength of the leaded end is an initial advantage only, and that after the cable has been in use for a time the leaded end is likely to be distinctly the weaker. The assumed initial strength of the leaded end may also be fictitious, for the wires sometimes pull out of these ends while they are in service. A good end, made with zinc in a laboratory, and by a specially skilled man, may be an entirely different thing from an end made with lead, in the building where the elevator is situated, and by a local engineer who may know little or nothing about work of this kind.

Derricks and other similar devices for hoisting materials are commonly rigged with clips or their equivalents, and leaded ends are rarely used in construction work, except on suspended scaffolds. The argument that leaded ends present a neater appearance should have no weight whatever in fitting up an elevator.

We do not mean to say that the leaded ends of elevator cables are hazardous to the degree that they should all be taken off forthwith, and replaced by clip fastenings. We strongly favor the clips, but we are well aware that it is the prevailing practice to use the leaded ends, and that they will be met with in perhaps ninety per cent of all the elevator cables that are in use.

* Reproduced from *The Travelers Standard.*

Fuel Briquets in America

SOME progress has been made in the development of fuel briquetting in the United States during the last two years, but this country still lags far behind some European countries, notably Germany. In 1911 the American production was 218,443 tons, valued at $808,721—almost double that of 1909. The subject of briquetting is one to which attention should be given, as on it depends to a considerable degree the utilization of some grades of fuel which should be made useful, but which are now wasted or sold at less than the actual cost of production. The reprehensible but apparently growing practice of shooting bituminous coal "off the solid" (and this is notably prevalent in the non-coking coal fields of the Mississippi Valley) produces an inordinate proportion of slack, an undesirable product, which it is difficult or impossible to sell, and, in fact, by the best mining practice the quantity of slack produced is frequently too large to be profitably disposed of. Some of it, quite significant quantities indeed, are used as powdered fuel in the manufacture of cement; but its use under boilers is unsatisfactory, as in the high heat of combustion the ash is fused and is deposited as a glassy material on the boiler tubes, and thus eventually produces an insulating covering which destroys the efficiency of the plant. The principal factor militating against the more rapid development of fuel briquetting in the non-coking coal fields of the Middle West is the low price of the raw fuel with which the manufactured product has to compete, and as long as new areas can be opened without restriction and the supply of cheap coal continued, so long will the present profligacy be maintained and the slack continue to be unused except to a limited degree.—*The Chemical Engineer.*

To Our Readers' Attention

In our issue of August 17th we published a frontispiece and several illustrations showing electric welding machines in use. The description given in the text referred mainly to a welding machine of English manufacture, while most of the illustration related—as implied in the captions—to an American make, the products of the Thomson Electric Welding Company of Lynn, Mass. Our attention has been drawn to the fact that some readers may have gained the impression that the illustrations related to the Prescot welder, manufactured by the British Insulated and Helsby Cables, Ltd. It is only fair that we should correct any such misapprehension which may have arisen. The illustrations, except Fig. 4, referred to the Thomson welder, while the diagram **Fig. 4 may** be taken equally well to refer to either machine.

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Table of Contents

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